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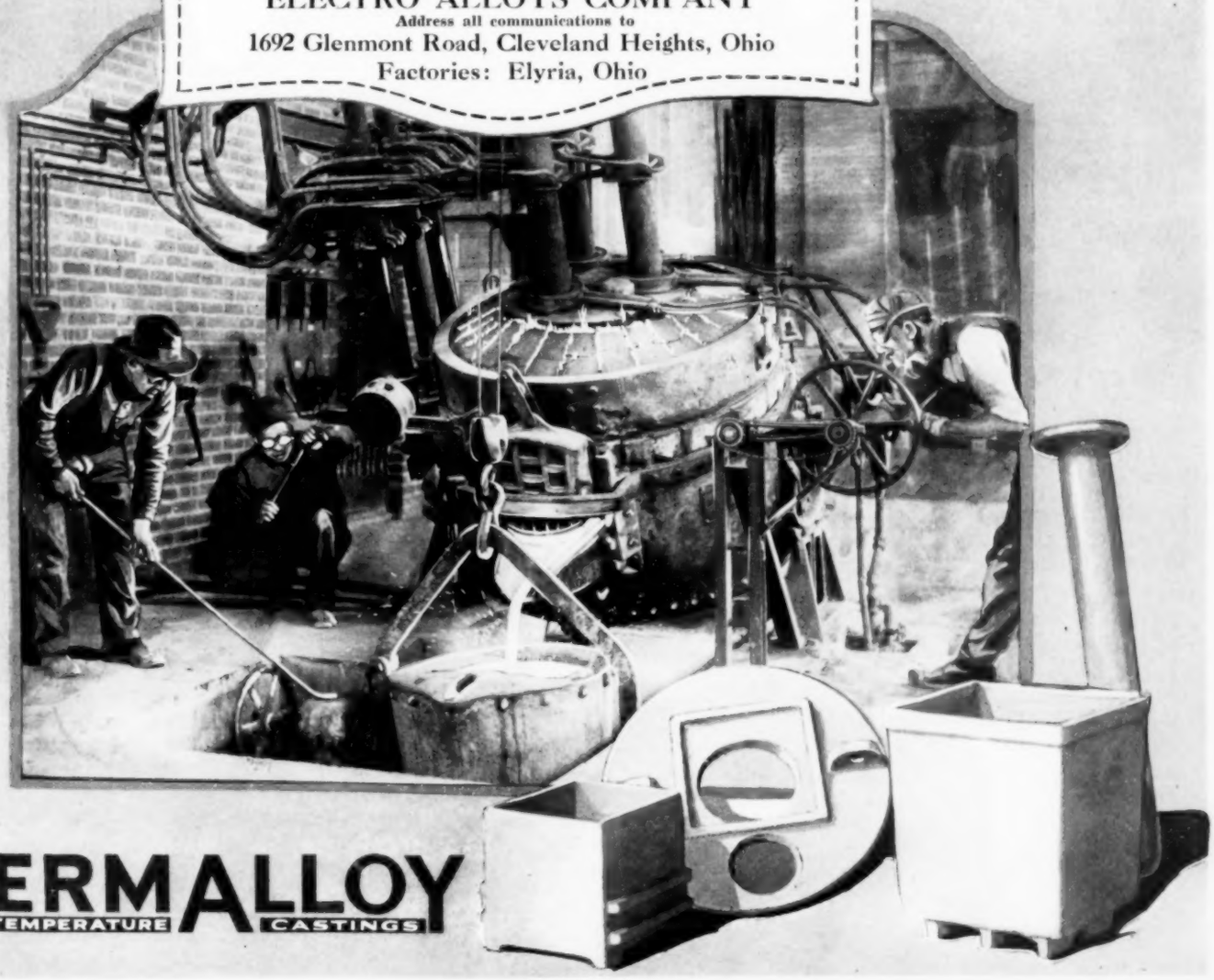

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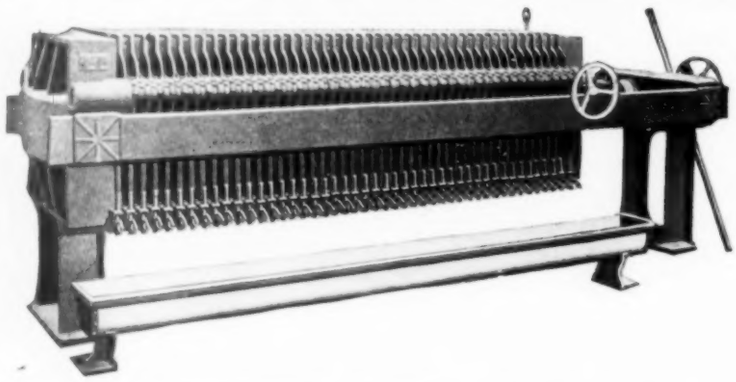

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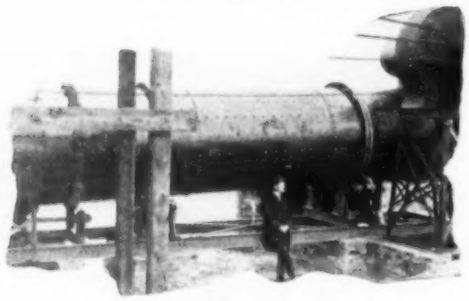

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## Prevention of Food Waste
### Aim of Research Institute

THE happy-go-lucky manner in which this country has blundered through every war in which it has ever engaged indicates that the forefathers adopted a fitting motto, "In GOD we trust." With the exception of maintaining a Navy and a skeleton of an Army, we have never made any preparation until actual hostilities were begun.

In the matter of food supply for our forces in the field we have been notoriously and sometimes criminally lax. Fortunately the commissariat was arranged better in the late war than in the conflict with Spain, which tarnished many reputations, though it fattened some pocketbooks. But feeding the army in the field is only a small part of the problem. There is the vast army at home whose work in winning a war is not less important than that of the fighting forces. HERBERT HOOVER and the Allied food administrators faced a task as hard as that of any general on the firing line—that of seeing that food was produced in sufficient quantities and distributed so as to insure the maximum efficiency. Things were ordered differently in Germany. There the whole matter had been thought out and when the war came the system of feeding the industrial army worked like the well-oiled machine it was.

When the food administrators of the Allied and associated countries met during the late war they agreed to do all in their power to secure a systematic study of this matter in their respective countries so that some kind of system might be available in another emergency. With the close of the war Mr. HOOVER did not forget this agreement. As there seemed to be no chance to get the Government to act in the matter, he went to work in his characteristic manner to get action in some other way. Due to his efforts the Carnegie Corporation has agreed to furnish the finances for a period of seven to ten years and the Food Research Institute of Stanford University has been brought into being. Its work will be divided into three groups, each in charge of a director. One group will study the economic and statistical features, another will study nutrition and the third will study the industrial side. Only one director has as yet been chosen, Dr. C. L. ALSBERG, who will be at the head of the third group. It is promised that the men appointed to the other directorships will be of equally high caliber.

It should not be necessary to wait for a war to prove the advantages of such a work as will be undertaken by the Food Research Institute. It is important in peace time that the industrial army—which takes in pretty nearly all of us—should be fed adequately and properly.

There is enormous waste in our system of food distribution, lack of statistics and other economic data and poorly organized knowledge of nutrition. Why should we wait until a war or some national emergency compels us to investigate these problems and correlate the findings? The Food Research Institute will be a means for determining the facts. The mechanism for availing ourselves fully of the findings and putting them to practical use does not yet appear, but undoubtedly it will be evolved later, so that not only will the hopes of the founders be justified but a distinct service will result to the whole country.

## Idealism Tempered
### With Common Sense

IN THE INDUSTRIAL life of a young and growing nation such as this there is often a tendency to the superlative in ideal or ambition that cannot altogether be justified. This perhaps is the excuse for the existence of pessimists, much as we hate that sort of creature. It is well, however, without becoming a pessimist, that we should temper our ambitions and our idealism with a generous measure of common sense.

Industrially the application of this principle means a careful consideration of the relative merits of old and new processes. That a new process is technically successful is not enough; it must also be a demonstrated commercial achievement before any great credit can be given to it in "practical affairs." The new process or product must afford a sufficiently wide margin of advantage above the old or current practice in order to justify a certain measure of risk in its adoption. One must never forget that any new development may prove to have altogether unsuspected deficiencies or defects. A wider margin of apparent advantage is, therefore, necessary to offset such possible contingencies.

Moreover, if the new process or product requires new investment it is very important to have a margin of financial profit sufficient to provide for the amortization of the old equipment or investment which must be discarded. Industrially there is little fear that this last factor will be ignored, for the banker, to whom we all go for the last word regarding new developments, is very careful to have this phase of new investment carefully considered before he will arrange for loans.

The research man often has what appears to him brilliant developments to offer, but finds unsympathetic or inattentive listeners when he presents his ideas for commercial development. Perhaps he may avoid the embarrassment of premature presentation of his projects and secure a more sympathetic hearing if he will bear in mind that it is necessary to present a certain margin of advance before he can claim to have made any real achievement. If he will do so he will contribute not only more to industry but also more to the advancement of research itself. This is particularly true in circumstances where partially developed, "half-baked" research is presented for the approval of management. Naturally the manager after repeated

experience of this sort is inclined to look with doubt upon all new developments offered from the research department, a result most unfortunate to that department and to the management as well.

## The Merit and Value of Ceremony

THERE was a quality about that celebration at the Chemists' Club on March 17 that makes an interesting subject for discussion. The conferring of honorary membership on eight great chemists was made a very formal occasion. Every word and every move were planned beforehand; nothing was done offhand, and, thanks to Dr. BASKERVILLE, who was chairman of the committee of arrangements, an impressive ceremony was devised.

Well, what's the use of ceremony anyway? Men of science have neither the "livery of heaven" nor professional millinery. It is their principal business to think straight and to talk straight; their symbols represent definite concepts and not, like the astrologer's pointed cap, mystic twaddle, or even any claim of authority. They have no robes of office or insignia of power; they wield neither magic wand nor scepter. Why wouldn't it be the sensible thing, if a body of chemists wants to make someone an honorary member, for the secretary to write him a letter, telling him of the fact, and then to let it go at that? The men would know, and all the business would be completed without any fuss or feathers.

We think the authorities of the club were wise in their generation in taking the opposite view. We live by symbols. We raise our hand and take an oath and then we are "under oath." If we lie at such a time there are dire consequences awaiting us. When a judge mounts the bench he wears his robe of office. When a policeman goes upon his beat to keep the peace he dresses for the part he is to take and he wears a uniform with brass buttons and a shield. The President of the United States does not wear a uniform, but he is encompassed by the White House, which is an official symbol of place. When the president of a university confers a degree he doesn't dictate a letter and post it to the recipient; he confers the honor with great dignity and formality. It is right that a distinguished occasion should be characterized by a fitting and proper ceremony. It makes a picture, and it is a serious mistake to think that anybody is too old or too wise to want to see a picture, or even to take a part in it.

Science has suffered from its informality. We claim participation in affairs, but we do not very often dress the part that we claim. We need to impress upon the rest of the world the dignity of science. Ceremony and formality are the gestures of life.

At the meeting in question there were eight distinguished members of the club appointed to meet, each one, the new honorary member or his representative, to whom he had been assigned, to conduct him upstairs and present him to the president, to escort him to dinner, and after dinner to escort him to the hall. Then when the president had called the meeting to order the chairman of the committee cited in alphabetical order, first those of the foreign nations present, then the Americans, by name, whereupon the escorting member stepped with his charge to the platform and formally presented him in words that had already been prepared. The president shook his hand, gave him a beautiful certificate of honorary membership, and assigned him to his seat on the platform under his national flag.

There were no little jokes, nobody tried to be funny, and no one was embarrassed. Or if anybody was he was not placed in a position to be ridiculous. We believe that all who were present will remember the occasion as one on which the things which were done were done right.

## Popular Appeal In Industrial Reels

THE people are the audience of the moving picture shows. They pay the price of admission primarily for amusement, which may be any form of mental satisfaction, comic, pathetic, educational, intelligent or otherwise. Propaganda films have a monopoly on the last three classifications, and especially of the last. Of the manufacturers HENRY FORD has probably propagandized most successfully, leaving the "otherwise" classification to his newspaper efforts. Ford reels have cultivated the acquaintance of the public by displays all the way from the marvels of the Detroit factory to touring through Florida in the winter and Canada in the summer à la Ford. Thousands of Fords on the highways could not begin to get the popular appeal that has been produced by these few thousand feet of picture reels.

Picture campaigns are costly, with negatives of interiors at four dollars per foot or second of display time. Movie operators ordinarily pay rent for the use of reels, but charge advertising rates for anything of a propaganda nature. Thirty thousand dollars per reel is said to be the average expense of covering the circuits throughout the United States, which makes the girls on the covers of our most popular magazines blush at their valuation.

Industrial movies in restricted circuits such as society meetings and educational institutions do not require silver wheels to put them across. While their function from the many selfish points of view may be limited, they have an influence that is well worth the effort spent to produce them.

## Popularizing Science

AT LAST chemists can welcome an agency of publicity which is generously endowed for the promotion of scientific matters which does not propose as the first step of its activity to publish a new magazine. The scientific literature of the country is already so extensive that technical men are overburdened with new periodicals. In fact, as one engineer recently remarked, "The first function of a new association always seems to be to rent an office and hire a secretary; the second, to get out a new magazine." It is a great pleasure, therefore, to find that Science Service takes an entirely different stand in its proposal to work only through existing publications.

This new Service, which is headed by Dr. EDWIN E. SLOSSON, as editor, and HOWARD WHEELER, as manager, is generously endowed. It seems certain to succeed in its effort to popularize scientific information; and if we may judge its prospects of success from the splendid work which its editor has done in his volumes on "Creative Chemistry" and "Easy Lessons in Einstein" it is assured a splendid future.

Chemists and engineers will be well served by the existence of such an agency, for it will do much good in bringing these professional men before the general public through new channels. It is contemplated that the popular press, motion pictures and lectures will all be used in furthering the ideals of Science Service, which include instruction of "the public about the methods employed by science in discovering the secrets of nature," and also in bringing before the general public "the means by which industry and science operate to make available and distribute these supplies (the natural resources of the country)."

Even the technical men of today find it difficult to keep in touch with all scientific and technologic literature which is of value to them. It is easy to realize how much more difficult it is for the lay public to get even an elementary idea of many developments in which it is generally interested. If Science Service can even in a small degree satisfy the popular craving for reliable and yet intensely interesting information of new or spectacular developments it will have accomplished great good for the sciences and the branches of engineering with which it deals. Every effort of scientific and technical men to support the Service will, therefore, be well expended.

## Rail Statistics For 1920

THE American Iron and Steel Institute reports the production of rails in the United States in 1920 at 2,604,116 gross tons, against 2,203,843 tons in 1919, about 1,900,000 tons in 1908 and 1914 and 3,977,887 tons in 1906, the record year for rail production. The production of late has been entirely of steel rails, the last iron rail production reported being 234 tons, in 1911. The rails made in 1920 were chiefly priced at $45 for bessemer and $47 for open-hearth, and higher, against prices of $28 for bessemer and $30 for open-hearth for many years prior to May 1, 1916.

The production of rails is not an index of railroad prosperity to anything like the extent that is commonly assumed. Of all classes of material bought by railroads, rails are among the least promising of increased revenue and the most dangerous to do without when needed. Ten years ago a much smaller tonnage of the total output was used for replacements than at present, while large tonnages were used for building new track. Long ago one function of branch lines of railroad was to remove the necessity of driving wagons through mud. The motor vehicle and highway improvement have filled that bill very largely, furnishing one of several reasons why additional branch lines are not built to so great an extent as formerly.

The decrease in the consumption of rails by the standard steam roads is really greater than appears from the production statistics. In 1906 total production was 3,977,887 tons, rail exports amounted to 328,036 tons, imports being 4,943 tons, while 284,612 tons of rails under forty-five pounds per yard were made, an unknown proportion of these light rails being exported. The domestic consumption of rails forty-five pounds and over was therefore about 3,500,000 tons. In 1920 production was 2,604,116 tons, including 489,043 tons of rails under fifty pounds per yard, exports were 594,634 tons and imports were 45,684 tons, making the domestic consumption of rails fifty pounds and over probably under 1,750,000 tons, or a decrease of 50 per cent from 1906, whereas the total production declined by only about 35 per cent. The increase in the manufacture of light rails in the fourteen years, 60 or 65 per cent, is an interesting point.

The domestic consumption of standard section rails last year was of course almost wholly for replacement purposes. The building of new line dwindled to insignificant proportions several years ago, and the laying of additional track has been very small of late. The occasion for rail replacement is not in all cases simply normal wear. On account of heavier wheel loads the requirements in a rail increase. The old rail deteriorates rapidly and is replaced by a rail that will bear up better. The improvement is partly in quality and partly by increasing the section. Twenty years ago the 100-pound rail was a rarity, but in 1920 729,118 tons of rails were rolled in sections 100 pounds and over.

Titanium-treated rails came back a trifle in 1920, the tonnage so treated being 11,652 tons, against 6,207 tons in 1919 and 2,891 tons in 1918, the low year for titanium. In 1910 256,759 tons of rails were made with titanium treatment, but three years later less than one-fifth as many tons.

## Theoretical Organic Chemistry and Synthetic Chemical Technology

ORGANIC chemists are becoming less and less dependent on their knowledge of college lecture blackboard reactions showing the interaction of constituent groups of molecules taking place to suit the fancy of the crayonist. They are culling over the mass of descriptive records available in the literature and gradually evolving a few generalizations. If these prove to be useful they will sooner or later become a part of theoretical organic chemistry, and be applied in organic chemical technology.

The organic chemist, for example, knows that benzoic acid has not been prepared by the simple addition of carbon dioxide to benzene or monoxide to phenol. If he is a student of catalysis he may try to find a material that will induce carboxyl addition. It is accomplished in the synthesis of salicylic acid under the influence of the hydroxyl group and there is no evidence leading to the conclusion that results along catalytic lines cannot be obtained. Nevertheless sulphur and other catalyzer poisons are not removed from the purest commercial benzene to the extent of not being lethal in cumulative doses to such catalysts as nickel, and so the practical possibilities of such a process are indeed limited.

In substitution methods the organic chemist finds a much easier mode of attack. With toluene as the source the synthesis deals with simple atomic reactions, chlorine being substituted for the hydrogen in the radical with comparative ease and giving a product that can readily be hydrolyzed to benzoic acid. With benzene as the initial material the reaction deals with group molecular subdivisions and is very difficult to control. In this issue the investigation of Prof. McKEE and Dr. STRAUSS is being published not because it suggests a revolution in benzoic acid technology but as an example of diligent synthetic work along particularly difficult lines. The groups transferred are not atomically inactive to each other and of course the sulphonic group tends to be reduced and the other oxidized. The authors show considerable technique in handling the investigation and certainly have contributed in full measure to the literature in a spot where it is rather meager.

# Readers' Views and Comments

## A Compilation of American Dye Patents in Abstract Form

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—Early in the development of the Color Investigation Laboratory the need was felt for a compilation of the American patents on dyes, and Miss Aida M. Doyle, at that time employed by this laboratory, undertook the task. It was our intention to publish it, but, owing to its size and the lack of funds available for such a publication from the Department of Agriculture, it has been found that it is impossible to do so. Consequently, the Bureau of Chemistry has decided to call the attention of those interested in such a work to the fact that the Color Investigation Laboratory has this in its files, where it may be consulted at any time. It should be borne in mind, however, that it is not possible for the laboratory to undertake patent searches.

The compilation is in the following form:

Each patent was abstracted under seven different headings, in order to make the compilation accessible from as many points of inquiry as possible. The abstract was typed on 3 x 5-in. cards, of which as many copies were made as was necessary. A separate file was made for each of the seven headings, so that it is completely cross-indexed, and any patent may be found in any one of seven different ways:

1. Scientific name, when known or given in the patent.
2. Intermediates used, with a very condensed statement of the method of manufacture.
3. Class of dye, according to Schultz's eighteen chemical classes.
4. Color of dye.
5. Method of use.
6. Fiber or material for which suitable.
7. Name of owner, and, in parentheses, name of patentee.

In making the first file, it was found that the scientific name was so seldom given and was apparently of so little importance that the file was finally arranged in strict numerical order. Besides the above information the number and date of patent are given, and, in the upper right hand corner, the Schultz number of the dye, when it is possible to locate it, together with the most common trade name, or the trade name given in the patent itself. Any additional information is added as a note at the bottom of the card. The chemical nomenclature and abbreviations used are those sponsored by *Chemical Abstracts*.

In order to make the explanation more intelligible, a specimen card is herewith reproduced.

| No. 546,177<br>9-10-1895 | S. No. 607<br>"Rheonin A."<br>BENZOPHENONE condensed with *m*-PHENYLENE DIAMIN HCl and *m*-PHENYLENE DIAMIN by heating with $ZnCl_2$ in closed enameled vessel, on oil bath to 195-215 deg. The *m*-amino phenyl AURAMIN first formed combines with diamin to form the new dye. |
|---|---|
| 1. Product like phosphine in properties | |
| 2. Tetra methyl diamin | |
| 3. Acridin | |
| 4. Yellow, brownish- | |
| 5. Basic mordant | |
| 6. Cotton, leather | |
| 7. Badische (C. L. Müller). | |

It is to be seen that the abstracts, and the whole compilation in fact, are not intended to do away with the consulting of the patents themselves, but merely to serve as a cross-index to them. At the same time the cards contain enough information to enable the user to decide which of several possible patents is the one he is looking for, without the necessity of handling the patents themselves, thus cutting down on their wear and tear as well as saving his time.

The compilation has been brought up to date of Jan. 1, 1921, by Max Phillips and Dr. L. D. Smith of this laboratory, and will be kept as complete as possible.

Any one desiring to make use of this compilation should either visit or address the Color Investigation Laboratory.

JOSEPH A. AMBLER,
Acting Chemist-in-Charge.

Color Investigation Laboratory,
Bureau of Chemistry,
Department of Agriculture,
Washington, D. C.

## Senatorial Science

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—The venerable Senators of the United States in high conclave assembled undertook on Feb. 25 last to discuss fertilizer materials. It had to do with an appropriation of $86,000 "to determine possible sources of supply and methods of obtaining potash, nitrates and other natural fertilizers." The discourse of these learned men was so illuminating that I cannot forbear to copy some of their words of wisdom from the *Congressional Record*, in the hope that you will give your readers the benefit.

> BY SENATOR WALSH: The Geological Survey has issued numerous bulletins concerning the supply of potash and nitrates . . . which have been referred to from time to time on the floor here. Bear in mind, I commend the investigation as one that ought to be encouraged, but we are certainly embarking the Agricultural Department in investigations that are particularly appropriate to mining operations.
>
> SENATOR FLETCHER: In some respects it pertains to mining operations, but in other respects I think the investigation does not; because the Agricultural Department is making experiments now in the matter of developing potash, nitrates and acids for reducing potash into sulphate of ammonia, ammonium potash and so forth.

Here we have a balance of originality. Senator Walsh contributes the mining note on the fixation of nitrogen which disturbs Senator Fletcher's chemical conscience. As an offset to his conservatism, on the other hand, he gives us the new reaction of potash to ammonium sulphate and the new product, ammonium potash.

Senator Smith of South Carolina reminded his colleagues that the Department of Agriculture had made extensive investigations and reports in regard to obtaining potash from the kelp weed, to which Senator Walsh replied: "If the Senator from South Carolina will permit me, that is entirely proper. Kelp is an *agricultural product*. . . . There is also considerable quantity of potash discovered *in reducing coal to coke*. . . ."

We have made bold to italicize the new features of the learned Senator's comment.

Senator McNary thought they were drifting afield under the lead of Senator Smith. He did not think the appropriation indicated the performance of any

work in connection with processes for obtaining potash from kelp. "I think," said he, "the appropriation in the item under discussion is not even used for the purpose of studying the habits of the nitrates that may be obtained from leguminous plants." Here is a chance for cheap celluloid by the McNary process. Extract your cellulose already nitrated from the nitrated legumes, mix it with camphor, press it, and there you are! This should gladden the heart of Clarence Joyce if he sees it. Senator Smoot thought that the work should be done by the Bureau of Mines and the Geological Survey, because "Potash deposits are frequently found on public lands, for instance."

"Neither of these services actually makes experiments, as I take it," said Senator Fletcher. "They merely locate deposits and map and plot them, and that sort of thing, and show where the products possibly can be obtained, but the Department of Agriculture has a bureau which actually experiments with these different elements to determine the commercial value of the product."

Alas for Dr. Charles L. Parsons! Eheu, Dr. Cottrell! Væ, Dr. R. B. Moore! Senator Fletcher is in Washington; he is on the spot; and his remarks would seem to indicate that all these three gentlemen, as consecutive chief chemists to the Bureau of Mines, had been twirling their thumbs in idleness for years and years and years. We can hardly believe it. For a fact, we don't. Indeed, Senator Smoot corrected him. He told how the Bureau of Mines had spent hundreds of thousands of dollars for the investigation of "certain rock deposits in New Jersey for the purpose of extracting potash from the same." We take it that the "certain rock deposits" are green sands. He also said that the Bureau of Mines had "spent thousands and tens of thousands of dollars in developing the nitrate deposits in America." He probably referred to our aërial deposits of nitrogen.

Later in the discussion Senator Smoot said that "the great bulk of potash produced in the United States—and this statement will be as true in the future—has come from the extraction of potash or nitrates from the rocks which are found in the everlasting hills of the West." We can't help wondering whether those hills will be everlasting after "the potash or nitrates" have been taken out of them.

The argument as to the relative merits of the Agricultural Department and the Bureau of Mines would not down. Senator Fletcher thought the Department of Agriculture should determine "the source of fertilizer, the elements which enter into plant food, and the way to develop them and make them available to the producers of the food of the country on reasonable terms."

Senator Smoot objected, on the ground that "the scientists in the Department who have been educated to study questions relating to plant life, growth, development and other matters connected with the soil are not the ones to handle it. It takes men who have studied for years and years along a particular line, who have studied the geology of the country, and more than likely who have spent their early lives in the mines of the West. It takes practical men."

That looks like a swat at Dr. Alsberg of the Bureau of Chemistry. How many of his chemists can he point out who have spent their early years in the mines of the West?

Senator Walsh of Montana brought up the Searles Lake deposits, and said that not only had the Geological Survey made repeated reports on it but that investigations by Congress had also been conducted and that the information so derived was also available.

A congressional investigation into salt brines would be interesting.

Senator Walsh resented the appropriation of $5,000 to care for the machinery at the experimental kelp plant in California. "Private enterprise," said he, in regard to kelp, "is now engaged in the development of this source of supply of nitrate and it is not necessary for the Government to carry it on any longer."

This, Mr. Editor, is from the Senate of the United States; not the Senate of the Sovereign State of Nevada or of Arkansas. It is "the highest deliberative body in the world." Good Lord! MARTIN SEYT.

## Compensation of Chemists and Salesmen

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—Mr. Ferguson's letter in your March 16 number headed "Compensation of Chemists and Salesmen" is interesting. Permit me to say, however, that while perhaps there are cases where chemists are insufficiently paid or are seemingly unappreciated, as is true in all walks of life, and that the law of supply and demand affects to some extent chemists' salaries, yet in the vast majority of cases I believe chemists are paid in direct proportion to the delivery they make.

When chemists are paid relatively low salaries it is probably because of their faulty training, their lack of practical horse sense and their inability to sense proportions. I am afraid Mr. Ferguson is not fully informed as to what "the average employer" is paying either his salesmen or his chemists, nor what these salesmen and chemists are *paying* their employer. At any rate, comparisons between chemists and salesmen are scarcely more illuminating than comparisons between chemists and college professors, twelve-dollar-a-day brick masons, or bank presidents. Business is a hard and ceaseless struggle and the employee, be he chemist, salesman or executive, who shows greatest results receives the greatest reward in the long run. CHEMIST.

Chicago, Ill.

## Temperature Conversion Tables

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—We have had occasion to use almost daily your "Temperature Conversion Tables," as included in the Dec. 1 number of CHEMICAL & METALLURGICAL ENGINEERING, page 1075.

We have found in one small section of the table an error of exactly 1 deg. F. that is carried along for four consecutive temperatures. In converting from degrees Centigrade to degrees Fahrenheit the figures given are correct when converting from 15 deg. and from 20 deg. C. The error comes in the conversion from 16, 17, 18 and 19 deg. C. respectively, and amounts in each case to exactly +1 deg. F. Presumably the calculator of the conversions obtained the 15-deg. and 20-deg. C. values by use of the formula, and the values for the intermediate degrees by successive additions of 1.8. In the section in question the error came in adding 2.8 in one case and 0.8 in the other, instead of 1.8.

We call your attention to this error in the tables, because of their great excellence otherwise.

W. C. HOLMES.

E. I. du Pont de Nemours & Co.,
Chester, Pa.

# Synthesis of Chlorine-Free Benzoic Acid From Benzene—I

## An Investigation on the Synthesis of Chlorine-Free Benzoic Acid by Sulphonation of Benzene and Substitution by Carboxyl Group—Formate Fusion Method—Cyanide Fusion and Hydrolysis of Benzonitrile Method*

By RALPH H. McKEE, Ph.D., and FRANK A. STRAUSS

ALTHOUGH a variety of processes for the synthesis of benzoic acid have been proposed, the acid on the market today is made almost exclusively from toluene. The following investigation was undertaken to develop a commercial method for the synthesis of chlorine-free benzoic acid from benzene. An obscure and neglected reaction has been studied, modifications in the reaction conditions whereby a greatly increased yield is obtainable have been worked out, and some of the problems of the commercial application of the process have been touched upon. It is believed that a method is outlined herein for the manufacture of benzoic acid of high purity at a cost which compares favorably with that of the present method of production. The process, moreover, is of especial interest in connection with recent developments in the production of cheap cyanides from atmospheric nitrogen, for which new uses are being sought. It is also of interest in that it makes use of sodium benzene sulphonate, and thus offers a means of employing a part of the extensive idle equipment used in the manufacture of synthetic phenol during the war.

### Historical and Bibliographical Review

Benzoic acid owes its name to its occurrence in gum benzoin. First mentioned in 1608 by Blaise de Vigenére, its preparation was described first by Scheele in 1755. Its structure was established by the classic work of Wöhler[1] and Mitscherlich.[2]

The processes used or proposed for the manufacture of benzoic acid may conveniently be classified according to the starting material.

### Manufacture From Vegetable and Animal Sources —Production From Gum Benzoin

This was the first source of benzoic acid, and even today is said to furnish a small amount of the pharmaceutical product. The acid may be obtained by sublimation,[3] by steam distillation,[4] by extraction with alcohol[5] or by digestion with alkali.[6] A yield equal to 25 per cent of the weight of the gum is obtainable. Other resins, such as Siam, Palembang and gum acroides may be used.

### Production From Animal Sources

The urine of herbivora contains small amounts of hippuric acid, $C_6H_5CONHCH_2COOH$, which on hydrolysis gives benzoic acid. About 1870 small amounts of the acid were made commercially from this source in Germany and Austria,[7] but the process has long since been abandoned. Benzoic acid has also been prepared from suint (crude wool grease).[8]

### Manufacture From Products of Distillation of Coal —From Benzene

Direct synthesis by the Friedel-Crafts reaction from benzene and carbon dioxide in the presence of aluminum chloride is said to have been tried on a commercial scale in France.[9]

During the war, one American manufacturer converted aniline into benzonitrile by the Sandmeyer reaction (diazotization and treatment with cuprous cyanide), and hydrolyzed the nitrile to benzoic acid.

The manufacture of benzonitrile by the action of copper on phenyl isothiocyanate or diphenylthiourea has been proposed.[10]

Benzonitrile may also be synthesized by passing chlorbenzene over heated alkali cyanide or ferrocyanide.[11] As the best yields reported are 22 per cent, the method seems of little interest. A process has recently been patented[12] in which lower temperatures and the presence of a catalyst are specified.

### From Toluene

Toluene may be oxidized to benzoic acid either directly or by chlorination with subsequent hydrolysis.

Among the agents for direct oxidation which have been proposed are:

*a.* Air in the presence of a heated catalyst, such as: porous carbon or iron oxide;[13] vanadium or molybdenum oxide;[14] platinum.[15]

*b.* Ozone.[16]

*c.* Nickel oxide.[17]

*d.* Nitric acid.[18] The yields are fair, but the method is expensive. Two American manufacturers are using it in order to obtain a product free from chlorine.

*e.* Potassium permanganate.[19]

*f.* Manganese dioxide and acid. A wide range of

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[1] *Annalen*, vol. 3, p. 249 (1832).

[2] *Annalen*, vol. 9, p. 39 (1834).

[3] Mohr, *Annalen*, vol. 29, p. 177 (1839); Starting, *Archiv. Pharm.*, vol. 231, p. 342 (1893); Loewe, *J. Prakt. Chem.*, vol. 108, p. 257 (1869); *U. S. Pharmacopoeia*, vol. 5 (1870).

[4] Scharling, *Am. J. Pharm.*, vol. 24, p. 236 (1852).

[5] Wöhler, *Annalen*, vol. 49, p. 245 (1844).

[6] *U. S. Dispensatory*, vol. 17, p. 33 (1894). This was Scheele's original method.

[7] Hofman, *Wien. Weltausstellungsbericht.* (1877), vol. 3, p. 431; Ullman, *Encyclopaedie der Technische Chemie* (1915), vol. 2, p. 325; Caseneuve, *Zeitschr. Oest. Apothek. Ver.* (1879), p. 2. *U. S. Dispensatory*, vol. 17, *loc. cit.*

[8] *Chemist and Druggist* (1876), p. 358; *U. S. Dispensatory*, *loc. cit.*

[9] Frydlender, *Rev. Prod. Chim.*, vol. 21, p. 24 (1918).

[10] Badische Anilin u. Sodafabrik, Ger. Pats. 259,363, 259,364; Eng. Pat. 28,647 (1912); French Pat. 456,086.

[11] Merz and Schelnberger, *Berichte*, vol. 8, p. 918 (1875); Merz and Weith, *Berichte*, vol. 10, p. 746 (1877).

[12] Akt. Ges. f. Anilinfabrikation, Ger. Pat. 293,094.

[13] Chavy, Delage and Woog, French Pat. 379,715.

[14] Gibbs, U S. Pat. 1,284,887; Eng. Pat. 119,518 (1917). See also Walter, *J. Prakt. Chem.*, vol. 159, p. 107 (1895); Ger. Pat. 168,291, French Pat. 360,785, Eng. Pat. 21,941 (1905).

[15] Coquillon, *Compt. rend.*, vol. 80, p. 1089 (1875).

[16] Heinemann, Eng. Pat. 23,575 (1914).

[17] Badische Anilin u. Sodafabrik, Ger. Pat. 127,388, U. S. Pat. 698,355, Eng. Pat. 32,887 (1900), French Pat. 306,071.

[18] Fittig, *Annalen*, vol. 120, p. 214 (1861); Grimaux and Lauth, *Bull. Soc. Chim.* (3), vol. 7, p. 100 (1892); Sacchse, Ger. Pat. 216,091; Coblentz and Walker, U. S. Pat. 1,332,028.

[19] Ullman and Uzbachian, *Berichte*, vol. 36, p. 1797 (1903).

conditions has been patented.[20] The process is said to have been carried out abroad on a commercial scale.[21]

*g*. Chromic acid mixture. Toluene is oxidized in vapor form,[22] or in the cold in the presence of iron, cerium or manganese compounds.[23]

Manufacture by chlorination with subsequent hydrolysis has been the subject of much experimental work, and the literature abounds in references.[24] All three of the side-chain substituted compounds have been used.

Benzyl chloride, $C_6H_5CH_2Cl$, seems to be the starting material at present most generally used by American manufacturers. It is usually simultaneously hydrolyzed and oxidized with a warm slurry of bleaching powder. A number of variations of the procedure have been described. Thus Jessnitzer[25] heated benzyl chloride or a mixture of benzyl and benzal chlorides with lime and chalk. Savage and the Weston Chemical Co.[26] first reflux benzyl chloride with caustic soda or lime of milk and then oxidize with calcium or sodium hypochlorite. Leach[27] proposes heating with alkali and then passing in chlorine. Nitric acid may be used as oxidizing agent.[28]

On hydrolyzing benzal chloride, $C_6H_5CHCl_2$, with alkali some benzoic acid is formed from the benzotrichloride present, and some also is formed secondarily from the simultaneous oxidation and reduction of two molecules of benzaldehyde. Considerable quantities of benzoic acid are obtained in this way as a byproduct in the manufacture of benzaldehyde.

Benzotrichloride, $C_6H_5CCl_3$, appears to be the starting material usually employed in German practice, and until recently in the United States as well; but at present the benzyl chloride method described above seems to be more generally used. The process of Schultze[29] has been widely employed. Benzotrichloride is decomposed with milk of lime in the presence of iron powder. Limpricht[30] hydrolyzed with water under pressure at 140 to 190 deg. This process was carried on commercially for a time.[31] Espenscheid[32] boiled with alkali containing solid matter to prevent the formation of two liquid layers. Janssen[33] has suggested the use of concentrated sulphuric or phosphoric acid in the cold. Jacobsen[34] prepared benzoyl chloride by heating with concentrated acetic acid and zinc chloride.

In the manufacture of saccharin considerable quantities of *m*- and *p*-sulphaminobenzoic acids are sometimes formed as byproducts. It has been proposed[35] to convert these compounds into benzoic acid by hydrolysis with superheated steam in acid solution.

### From Benzonitrile Contained in Coal Tar

The carbolic or creosote oil fraction of coal tar has been shown to contain a small amount of benzonitrile.[36] The manufacture of benzoic acid from this source by hydrolysis with alkali has been proposed.[37] The process was worked for a time at a plant near Vienna.[38]

### From Naphthalene Derivatives

Laurent and Castelraz[39] prepared benzoic acid commercially by distilling phthalic acid with lime about 1865. Laurent also manufactured benzoic acid from benzonitrile, prepared from phthalimide by heating with lime.[40] The Basler Chemische Fabrik has patented the production of benzoic acid from nitronaphthalene, nitronaphthols and phthalic acid by heating with alkali under pressure;[41] also by fusing naphthols or other naphthalene derivatives with alkali.[42] Gibbs and Conover state that benzoic acid is one of the products formed by the catalytic oxidation of naphthalene.[43]

### From Phenanthrene

The production of benzoic acid from phenanthrene by electrolytic oxidation has been proposed.[44]

### Disadvantages of the Present Process

Although the details of the manufacture of benzoic acid are in general trade secrets, it is known that the difficulties of large-scale working are considerable. For example, chlorination at elevated temperatures (preferably with chlorine in the vapor phase), or in the presence of phosphorus or sulphur[45] chlorides, or in direct sunlight or ultra-violet light, must be resorted to in order to obtain the desired side-chain substituted compounds. Even then some compounds with chlorine in the ring are invariably formed.[46] Chlorination in sunlight or ultra-violet light is apparently the chief method in use in this country at present.

The sunlight process requires small glass units in order that the maximum reacting surface may be exposed to the light. The containers are expensive, fragile and a specially designed building is necessary, and production is dependent on the weather season. If ultra-violet light is used the units are larger, but expensive installations of quartz lamps are required; moreover, the yield is said to be not so good as with sunlight.

The process requires a large amount of chlorine, either in the form of gas or as bleaching powder. Although chlorine is a commodity for which new uses are being sought, its present cost is not low, and its purification, liquefaction, transportation and storage present problems which limit its usefulness. Moreover, this chlorine is largely converted into offensive waste products whose handling and disposition are accompanied by difficulties, particularly if bleaching powder is used.

The crude benzoic acid must be purified by sublimation, a difficult works operation. Even after purification the product is contaminated with appreciable amounts

[20] Monnet, Ger. Pats. 101,221, 107,722; Eng. Pat. 22,121 (1897); French Pat. 276,258; U. S. Pat. 613,460; Badische Anilin u. Soda Fabrik, Ger. Pat. 175,295.
[21] Raschig, *Chem. Zeit.*, vol. 24, p. 446 (1900).
[22] Chem. Fabrik Buckau, Ger. Pat. 261,775.
[23] Dieffenbach and Alefeld, Ger. Pat. 311,051.
[24] For a description of processes of chlorinating toluene see Cain, "The Manufacture of Intermediate Products for Dyes," 1919, p. 15; Barnett, "Coal-Tar Dyes and Intermediates," 1919, p. 76.
[25] Ger. Pat. 236,489.
[26] Eng. Pat. 116,348 (1917).
[27] Eng. Pat. 132,433 (1919).
[28] Lunge and Petri, *Berichte*, vol. 10, p. 1275 (1875).
[29] Ger. Pats. 82,927, 85,493.
[30] *Annalen*, vol. 139, p. 324 (1866); Lubs and Clark, [*J. Am. Chem. Soc.*, vol. 40, p. 1449 (1918)] obtained complete hydrolysis at 100 deg. with agitation.
[31] Von Rad, *Dingler's Polytechn. J.*, vol. 231, p. 538 (1879).
[32] Ger. Pat. Application 47,187.
[33] Ger. Pat. 6,685; Eng. Pat. 889 (1879); French Pat. 129,220.
[34] Ger. Pats. 11,494, 13,127; Eng. Pat. 2,878 (1880); French Pat. 137,419.
[35] Fahlberg, Ger. Pat. 101,682; Eng. Pat. 10,955 (1895); French Pat. 247,894.
[36] Kraemer and Spilker, *Berichte*, vol. 23, p. 78 (1890).
[37] Aktienges. f. Teer u. Erdoelindustrie, Ger. Pat. 109,122; French Pat. 287,934; Eng. Pat. 7,867 (1899).
[38] Goldschmiedt, *Monatshefte f. Chem.*, vol. 28, p. 1091 (1907).
[39] *Dingler's Polytechn. J.*, vol. 175, p. 455 (1865).
[40] Frydlender, *loc. cit.*
[41] Ger. Pat. 136,410; Eng. Pat. 15,527 (1901); French Pat. 313,187; U. S. Pat. 702,171.
[42] Ger. Pats. 138,790, 139,956, 140,999.
[43] U. S. Pats. 1,284,888, 1,285,117; Eng. Pat. 119,518 (1917).
[44] Farbwerke vorm. Meister Lucius u. Bruening, Ger. Pat. 152,063; U. S. Pat. 729,502; Eng. Pat. 19,178 (1902); French Pat. 328,069.
[45] Kyrides, U. S. Pat. 1,345,373.
[46] Lubs and Clark (*loc. cit.*) give analyses of commercial chlorinated toluene such as is used in benzoic acid manufacture, origin not stated, but presumably typical. Two samples contained 2.9 per cent and 2.4 per cent ring chlorine respectively, corresponding to a chlorination in the ring of 13.2 per cent and 9.4 per cent of the toluene molecules present.

of chlor-compounds,[47] which are highly undesirable from a physiological viewpoint. The U. S. Pharmacopœia requirements as to chlorine content are rather indefinite, but it is well known that many lots offered as "U.S.P." contain appreciable amounts of chlorine. Benzoic acid free from chlorine commands a substantial premium on the market.

It is clear that these difficulties are inherent in the chlorination process, and although they may be minimized it is not likely that they can be eliminated entirely. The direct oxidation processes appear attractive because of their simplicity, but in practice they have not proved successful, partly because of the expense of the oxidizing agents and partly because of the poor yields. The other processes enumerated are manifestly of little commercial value, except perhaps under certain unusual conditions.

### Possibilities of a New Commercial Synthesis

None of the processes starting with benzene hitherto used or proposed show much likelihood of commercial applicability. The Friedel-Crafts reaction offers interesting possibilities, but, like many similar syntheses, must await a cheap supply of anhydrous aluminum chloride. The process using aniline under ordinary conditions is far too expensive. The chlorbenzene reaction would probably not give a chlorine-free product, even if good yields were obtainable, which is doubtful.

The use of sodium benzene sulphonate as the starting material, however, offers more promise. The manufacture of this salt has been the subject of intensive study during the last few years. The details have been worked out with great minuteness, and its production has been carried out on an enormous scale with great success.

There are two known reactions for the synthesis of benzoic acid from alkali benzene sulphonate. They give benzoic acid either (*a*) directly, on heating alkali benzene sulphonate with alkali formate, or (*b*) through the intermediate production of benzonitrile, on heating the alkali sulphonate with alkali cyanide.

These reactions were first described respectively by Victor Meyer[48] in 1870 and by Merz[49] in 1868. Neither author gives many details as to conditions, yields, etc. Neither reaction seems to have received much attention since that date. The yields in both cases were apparently poor. In view, however, of the great improvement in yields resulting from the careful study of reaction conditions in the synthesis of phenol it was believed that a similar study might achieve considerable imprevement in these reactions as well. The work which follows constitutes a record of this investigation and of the success obtained.

### The Formate Fusion Method

Although the reaction between potassium benzene sulphonate and sodium formate was first described by Meyer, the possibility of synthesizing the aromatic acid direct from the alkali sulphonate seems to have occurred first to Merz.[50] In 1867 he heated a mixture of sodium benzene sulphonate and sodium carbonate to "over 400 deg." and isolated from the resultant charred mass a small quantity of material which exhibited many of the properties of benzoic acid. No later investigator makes any reference to this work of Merz.

Three years later Meyer mixed together equal parts of sodium formate and potassium benzene sulphonate, and heated the mass. Benzoic acid was recovered from the reaction mixture. Meyer wrote the equation as:

$$NaCOOH + KSO_2C_6H_5 = NaHSO_2 + KCOOC_6H_5$$

The yield was apparently small. He applied the method of synthesis to a number of other aromatic acids and used it to determine the position of the sulphonic acid groups in benzene disulphonic acid.

As a means of synthesizing the aromatic acids this method received some slight attention from later workers.[51] However, because of the poor yields, better and less troublesome methods became generally employed and no reference to this reaction was found in the literature since 1886.

The work of Merz[52] on fusion with sodium carbonate was repeated, following his directions as closely as possible. A charred mass resulted which contained no more than a possible trace of benzoic acid. Because of its inherent improbability no further attention was paid to this reaction.

Meyer's work[53] was next repeated with careful temperature control. A mixture of 50 g. sodium formate and 50 g. dry potassium benzene sulphonate was fused in an iron pot with constant stirring. Temperatures were measured with a base-metal thermocouple. No appreciable reaction took place below 290 deg.

The temperature of the melt was then raised to 300 deg. Vigorous foaming set in, accompanied by clouds of white smoke of pungent, disagreeable odor. The melt became viscous, semi-solid, and finally formed a dark brown cake. Heating was continued for fifteen minutes at 300 to 310 deg. The evolution of fumes having then almost ceased, the mass was cooled, dissolved in water, filtered to free from carbonaceous material, and acidified. A copious yellowish precipitate was formed, which after purification was identified as benzoic acid by the melting point of a sublimed sample, color reaction with ferric chloride, and odor on heating. Yield of crude benzoic acid was 3 g., or about 9 per cent of theory, based on the sodium benzene sulphonate used.

Meyer states in a footnote that sodium benzene sulphonate does not give this reaction. It seemed worth while to investigate this point. A run was made just as before, with the substitution of sodium benzene sulphonate for the potassium salt. At 350 deg. a reaction occurred as before. Benzoic acid was recovered from the reaction mixture. Yield, 2 g., or about 6 per cent of theoretical.

These experiments indicate that benzoate formation takes place only at a high temperature, and is accompanied by a great amount of decomposition. Benzoate formation takes place only at a relatively high temperature and is accompanied by a great amount of charring and the formation of decomposition products. Not only is the sulphonate charred and decomposed, but the sodium formate also breaks down above 290 deg.[54] It is prob-

[47] Phillips and Gibbs [*J. Ind. Eng. Chem.*, vol. 12, p. 277 (1920)] give some data on crude benzoic acid and the losses accompanying its purification. Crude acid received from the manufacturer contained 7.57 per cent chlorine, calculated to a dry basis, of which 5.45 per cent was in the ring, corresponding to 23.9 per cent chlorbenzoic acid. The sublimed product contained up to 2.53 per cent Cl, although samples described as "very pure" containing 0.34 per cent Cl were obtained. Losses on sublimation ranged from 27 to 57 per cent of the acid originally present. These results were obtained in an investigation of a new method of sublimation and are not necessarily typical, yet they show how large the losses may become.

[48] *Annalen*, vol. 156, p. 273 (1870).

[49] *Zeitschr. f. Chem.*, vol. 11, p. 33 (1868).

[50] *Zeitschr. f. Chem.*, vol. 10, p. 433 (1867).

[51] Bibliography of Formate Fusion Method follows.

[52] *Berichte*, vol. 6, p. 876 (1873).

[53] *Cf.* Appendix Bibliography of the Formate Fusion Method.

[54] Merz and Weith, *Berichte*, vol. 15, p. 1507 (1882); Hoffman and Schibsted, *Berichte*, vol. 51, p. 139 (1918).

able that the disagreeable fumes evolved contain thiophenols and thio-ethers, since these products are readily formed by the interaction of sulphonates and reducing agents.[55] For these reasons it seems unlikely that the synthesis can have any practical value. The experiments are interesting, however, in that they show Meyer's observations on the behavior of the sodium salt to be in error. There is no appreciable difference in the reactivity of the sodium and the potassium salts other than that due to the higher temperature required to cause the former to react.

### Synthesis of Benzonitrile

Merz first distilled a mixture of equal parts of potassium benzene sulphonate and potassium cyanide from an iron retort and isolated benzonitrile from the oily distillate. He considered the reaction to be:

$$KSO_2C_6H_5 + KCN = C_6H_5CN + K_2SO_3$$

In addition to a yellowish red oil, ammonium carbonate and some ammonium cyanide collected in the receiver. The residue in the still contained carbon, potassium sulphide, potassium cyanate and potassium thiocyanate. The yield of benzoic acid formed from the nitrile on hydrolysis is given as 33 per cent, presumably based on the amount of potassium benzene sulphonate used.

Merz also applied this reaction to the synthesis of toluonitrile and naphthonitrile, and others have applied it to the synthesis of various aromatic and heterocyclic nitriles.[56] The yields in most cases were small, and the method has been quite generally abandoned in favor of the Sandmeyer reaction and others more suited to the organic laboratory. No one seems to have investigated the reaction carefully with a view to improving yields. Merz and Mühlhauser[57] described rather incompletely a few experiments in which the proportions of the components of the reaction mixture were varied. Witt[58] proposed the substitution of potassium ferrocyanide for the simple cyanide, claiming an increase in yield. Potassium ferrocyanide was used by a number of later workers in the synthesis of higher members of the series, and at least one laboratory manual[59] recommends its use. Tingle[60] in an investigation of various methods of synthesizing benzonitrile repeated Merz' work and obtained a yield of 26 per cent benzonitrile. Beyond these isolated instances the reaction seems to have received no study from its discovery to the present date.

### Outline of Experimental Work

A brief consideration of the reaction will show that the principal factors susceptible of variation are the temperature of the reaction, the pressure, and the composition of the reaction mixture. A series of runs was carried out in which the influence of each of these factors upon the yield of benzonitrile was determined. In most of these experiments sodium salts were used in place of potassium salts because of their greater importance from an economic point of view.

In addition, a study of the nature and quantity of the products of the reaction other than benzonitrile was made. The results obtained threw much light on the nature of the reaction and were of great practical importance, as they gave a basis for modification of the process whereby the yield was considerably increased.

In order to carry out under control a reaction of this sort an intimate mixing of the constituents and uniform heating of the mixture are essential. A closed steel vessel externally heated and provided with a delivery tube and stirrer was first tried. It was found, however, that the charge did not actually fuse, but only became pasty at the reaction temperature, whereupon the stirrer cut a channel for itself through the mass and became useless.

In the apparatus finally adopted the intimate contact required was obtained by mixing the materials beforehand, no stirring during distillation being attempted. Uniform and rapid heating was obtained by making the container relatively narrow and immersing it in a bath

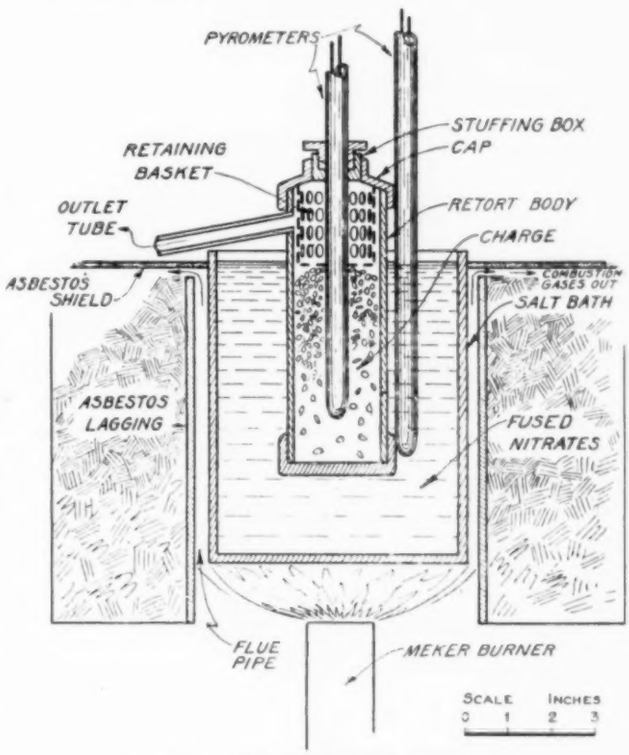


FIG. 1. EXPERIMENTAL RETORT

of fused salts. As the reaction is exothermic, this form of apparatus quite effectually minimized the undesired rise in temperature which would otherwise take place.

The apparatus is shown in Fig. 1. It was made for the most part of pipe fittings. The charge was contained in a vertical steel cylinder 2 in. in diameter and 6 in. long. The chamber was provided with a delivery tube 12 in. long inserted in the side near the top and inclined slightly downward. The chamber was closed by screw caps at top and bottom, a thermocouple passing through a stuffing box in the upper cap.

The salt bath, an equimolecular mixture of sodium and potassium nitrates, was contained in a steel pot 6 in. in diameter and 8 in. deep. The pot was set in a flue formed by a steel cylinder 7 in. in diameter and 9 in. long heavily lagged with asbestos magnesia pipe covering. Gas heating was employed. The temperature could be maintained within 3 to 5 deg. without difficulty, and with careful attention control within 2 deg. was possible, which was the least reading of the pyrometer.

The temperature of the system was measured by base-metal thermocouples and a calibrated millivoltmeter. One couple was immersed in the fused bath in contact with the retort a little below its center. The other was

[55] Capelli, *Gazz. Chim. Ital.*, vol. 48, II, p. 109 (1918).
[56] Bibliography follows. *Cf.* Appendix.
[57] *Berichte*, vol. 3, p. 709 (1870).
[58] *Berichte*, vol. 6, p. 448 (1873).
[59] Orndorff, Laboratory Manual of Organic Chemistry, Exp. 65.
[60] *Am. Chem. J.*, vol. 35, p. 87 (1906).

buried in the charge within the retort, the cold end projecting through the top cap. The cold ends of the thermocouples were maintained at a temperature close to that of the room, frequent measurements showing no variation greater than a degree or two. Hence no correction for this factor was required.

Normally the temperature within the retort during heating lagged behind that of the heating bath. When, however, the exothermic nature of the reaction was pronounced the inner temperature rose above that of the heating bath, as is shown by curves later on. Because of this discrepancy the outer temperature was taken as the criterion in all cases, the inner reading being used only as a check on the progress of the run.

The remainder of the apparatus was very simple. The delivery tube of the retort communicated with a large side-arm test tube in which the major portion of the liquid distillate collected. This receiver in turn was connected with an empty filter flask in which a small amount of distillate sometimes collected. When the evolved gases were examined they were collected over water in an 8-liter bottle. In the runs at reduced pressure the system was evacuated by a suction water pump.

### Materials and General Procedure

A high grade of commercial sodium cyanide, "sodium cyanide 96 to 98 per cent," was used. It was obtained in lump form, pulverized, and kept in stoppered bottles. Analysis after pulverizing showed a NaCN content of 94.19 per cent (by the Liebig method). This somewhat low figure is due at least in part to absorption of moisture, etc., during grinding.

The sodium benzene sulphonate was prepared from benzene by sulphonation, conversion into the calcium salt and careful conversion of the calcium salt to the sodium salt with sodium carbonate. The salt was powdered and dried at 120 deg. Its sodium benzene sulphonate content by the alcohol extraction method[a] was 95.1 per cent.

The course of a run was generally as follows: The requisite amounts of cyanide and sulphonate were weighed out rapidly and transferred to a porcelain jar mill. Usually quantities of materials were chosen such that the total weight of the charge was about 180 g. The charge was then simultaneously ground and mixed by tumbling in the mill. After thorough mixing the contents of the mill was rapidly charged into the retort. The retort was then closed tightly, immersed in the salt bath, which had been brought to the proper temperature, and the pyrometers and collecting train adjusted. As soon as the outside temperature reached the desired point the log of the run was started.

Readings of temperatures, time, etc., were ordinarily taken every ten minutes. The heating flame was carefully adjusted to keep the outside temperature at the desired point. When no more distillate came over heating was discontinued, the distillate removed and treated as described hereafter, and the retort removed and opened. In some runs a portion of the charge was found unchanged in the upper cooler part of the retort, where it had been forced by the evolution of gases. In such cases the charge was removed from the retort, broken up, returned, and the run continued as before.

The experimental work on the formation of benzonitrile may be divided into two main parts:

I. A detailed study of the products of the reaction.

II. A study of the effect of variations in reaction conditions on the yield of benzonitrile.

### The Products of the Reaction

The residue remaining in the retort was black, porous and friable, resembling soft coke. It was hygroscopic and usually had a slight odor of hydrogen sulphide. On treatment with water a black alkaline unfilterable liquid resulted, the color being due to colloidal carbonized material. The colloidal material was precipitated upon acidification or upon adding a salt of a heavy metal. The solution could then be filtered, and the filtrate was clear and colorless, or only slightly yellowish.

The analysis of this material presented many difficulties because of its complexity and because of its colloidal nature. Nevertheless satisfactory methods were finally devised. The results are believed to be quite as accurate as was consistent with the complex nature of the material and the manipulative difficulties of the analytical procedure. A brief description of the methods employed follows. Lack of space prevents discussion of many minor details of technique.

The residues contained, in addition to carbon, sodium carbonate, sulphate, sulphite, sulphide, thiocyanate and benzene sulphonate in varying proportions. Sulphate was determined gravimetrically on a portion after dissolving, acidifying, boiling vigorously and filtering out the insoluble carbonaceous matter. The latter was collected on a Gooch and weighed. To determine thiocyanate, a sample was dissolved in water, an excess of zinc sulphate added to precipitate sulphides, ferrocyanides and colloidal matter, the solution filtered, and the filtrate titrated with standard silver nitrate solution and ferric alum indicator after acidification.

Another portion of the sample was dissolved, treated with ammoniacal zinc sulphate, filtered, and sulphite determined in the filtrate iodometrically. The precipitate, containing the sulphide in the form of insoluble zinc sulphide, was transferred to an evolution flask, treated with hydrochloric acid, and the evolved hydrogen sulphide absorbed in ammoniacal cadmium chloride solution and determined iodometrically.

Cyanate was determined by hydrolyzing a sample with dilute acid (after the precipitation and removal of thiocyanate as the silver salt in acid solution) and determining the ammonia formed by distillation with alkali in the usual manner. To another sample a measured excess of standard acid was added, the solution filtered after an hour's standing, and the filtrate back titrated with alkali and methyl orange. From the data thus obtained the carbonate content was calculated, allowance being made for the acid consumed in hydrolyzing the cyanate and decomposing the sulphide present. Sodium benzene sulphonate was determined by extraction with alcohol after converting sodium cyanate and thiocyanate into the alcohol insoluble copper salts. Ferrocyanide when present was determined by the Williams method.[b]

Data showing the composition of the residue under varying conditions are given later on, and an interpretation of these results is reserved for that time. It will be sufficient to point out now that reaction products of such complexity and deviating so widely from the composition expected from theory indicate that extensive side-reactions must occur during heating.

[a] Boswell and Dickson, *J. Am. Chem. Soc.*, vol. 40, p. 1787 (1918).

[b] *J. Soc. Chem. Ind.*, vol. 31, p. 468 (1912).

The oily distillate, which consisted mainly of benzonitrile, varied in color from a light greenish brown to a very dark brown, becoming darker and cloudy during the course of a run. It was found that a rapid and fairly clean separation of the benzonitrile from the higher boiling constitutents of the oil could be effected by steam distillation. The two fractions thus obtained were examined separately.

The fraction volatile with steam accumulated during a number of runs was dried over calcium chloride. It had a pale straw color, the pleasant odor of benzonitrile, and density, *D* 15/15 = 1.021 (Westphal). A 100-c.c. sample distilled from a 250-c.c. flask gave the distillation curves plotted in Fig. 2, thereby showing the liquid to be substantially benzonitrile.[62] In order to determine the nature of the other compounds present, the first and last portions of the distillate were examined separately.

The first few drops distilling over had a disagreeable odor resembling phenyl isocyanide. They were shaken with cold concentrated hydrochloric acid to hydrolyze any isocyanide present. The acid solution was separated from the oil, neutralized, and a few drops added to a bleaching powder solution. An intense violet-red coloration resulted, indicating the presence of aniline, formed by the hydrolysis of phenyl isocyanide.

The presence of phenyl isocyanide (b.p. 165 deg.) is not surprising, as it is known that the normal and isocyanide exist together in equilibrium at elevated temperatures.[64] Alkyl cyanides prepared by distilling alkyl sulphates with alkali cyanides are always accompanied by a small amount of the isocyanide. Phenyl isocyanate (b.p. 166 deg.) has an odor similar to phenyl isocyanide and on hydrolysis would also give a test for aniline, but the density of the first 10 c.c. distilling (1.000) indicated the presence of phenyl isocyanate (*D* 0.9775) rather than the isocyanate (*D* 1.092).

The last portion was light yellow in color and deposited white crystals in the condenser and receiver. It had the odor and appearance of the first fraction obtained on distilling the oil non-volatile with steam. The crystals were identical with those separating from that fraction (gave same m.p., and m.p. of mixture was not lowered). The oil had the unmistakable odor of diphenylsulphide, the principal component of the fraction non-volatile with steam.

### The Fraction Non-Volatile With Steam

The residues from the steam distillation of the crude distillate were set aside. On standing a quantity of crystalline material separated out. The supernatant oil was poured off and the crystals retained for further examination. The oil was of a reddish brown color and had a rather pleasant sweet odor, density after drying over calcium chloride about 1.12. The upper curve, Fig. 2, was obtained on fractionating 133 g. of the dried oil from a 500-c.c. flask. All fractions of the distillate had the highly unpleasant odor associated with compounds of the thio-ether type.

The first and last portions of the distillate were cooled to —5 deg. and filtered to remove the white crystals which separated out. The crystals were washed with cold alcohol and reserved for further examination. The filtrates and middle fractions of the distillates were combined and refractioned twice. Ten c.c. of a yellow liquid of unpleasant leek-like odor, b.p. 294 to 297, *D* 15/15 = 1.114, was obtained.[65] Identification as diphenylsulphide was completed by oxidizing a portion to diphenylsulphone (m.p. 125 deg.) by the method of Stenhouse.[66]

The crystals separating from the crude oil on standing were washed with cold alcohol and recrystallized several times from benzene. From 4 g. of the original residue about 2 g. of a substance having the following properties was finally obtained: difficultly soluble in hot

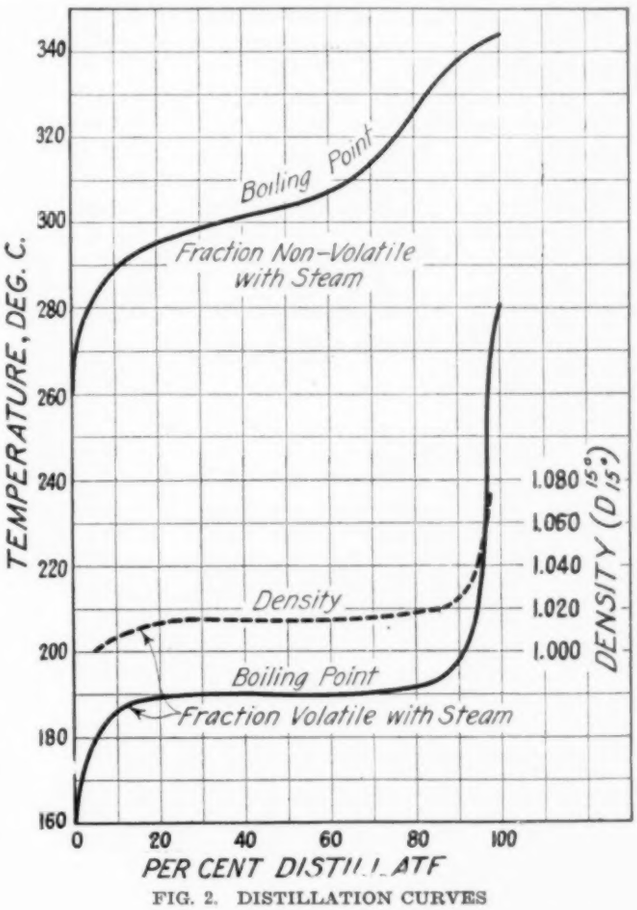


FIG. 2. DISTILLATION CURVES

alcohol, moderately soluble in cold and very soluble in hot benzene, crystallizing in hemispherical masses of white crystals, m.p. 158 deg. These properties[67] correspond closely to those of diphenylene disulphide $(C_6H_4)_2S_2$. Lack of material prevented more complete identification. The crystals separating from the high boiling fraction of the oil non-volatile with steam were also found to be diphenylene disulphide.

About 1 g. of crystalline material separated from the low-boiling fraction of the oil non-volatile with steam. After several recrystallizations from alcohol about 0.5 g. of short white needles, sparingly soluble in cold and very soluble in hot alcohol, soluble in benzene, m.p. 177 to 180 deg., was obtained. Lack of material prevented further identification.

To sum up: In addition to benzonitrile the following substances were isolated from the oily distillate: phenyl

[62] *D* 15/15 for benzonitrile = 1.0102 [Schneider, *Z. Physik. Chem.*, vol. 19, p. 157 (1896)]; b.p. 760 mm.: 190.7 deg. (Schneider); 191.3 deg. [Timmerman, *Bull.* Soc. Chim. Belg., vol. 24, p. 244 (1910); *Chem. Centralbl.* (1900) II, p. 442].

[64] Hoffman, *Annalen*, vol. 144, p. 114 (1867); Weith, *Berichte*, vol. 6, p. 213 (1873).

[65] B.p. of diphenylsulphide 296.5 deg., *D* 15/15 = 1.1185 [Perkin, *J. Chem. Soc.*, vol. 69, p. 1243 (1896)].

[66] *Annalen*, vol. 140, p. 290 (1866).

[67] Stenhouse, *Annalen*, vol. 140, p. 284 (1866); vol. 149, p. 247 (1869).

isocyanide; diphenylsulphide; solid, m.p. 177 to 180 deg., slightly volatile with steam; solid, m.p. 158 deg., b.p. over 300 deg., apparently diphenylene disulphide.

It might be well at this point to consider the source of some of these byproducts. The significance of phenyl isocyanide has already been discussed. Compounds of the thio-ether and thiophenol type are common products of the thermal decomposition of aromatic sulphonates. Stenhouse[8] isolated diphenylsulphide and diphenylene disulphide as well as thiophenol from the products of dry distillation of sodium benzene sulphonate. It is interesting to note, however, that he obtained considerable diphenylsulphide on distilling from a copper vessel, and considerable thiophenol, but little or no diphenylsulphide when an iron container was used. In the present experiments, though an iron vessel was employed, considerable diphenylsulphide was obtained. The isolation of thiophenol from the first fraction of the steam distillate was attempted, a portion being treated with alcoholic mercuric chloride after the usual method.[9] The result was negative. On applying the color test for thiophenol a few drops of the fraction gave only a faint coloration with concentrated sulphuric acid on long standing. Accordingly it is evident that the mechanism by which diphenylsulphide forms on distilling a mixture of sodium benzene sulphonate and sodium cyanide differs essentially from that by which sodium benzene sulphonate alone decomposes on heating.

This is also indicated by the temperatures at which the two reactions take place. It was found that sodium benzene sulphonate alone can be held at the temperature of these experiments (410 to 440 deg.) indefinitely without decomposition. Only on heating above its melting point (450 deg.) does decomposition take place. The presence of sodium cyanide and of the products of the benzonitrile reaction seems to be responsible, at least in part, for the formation of sulphur compounds. The following are possible, perhaps even probable, reactions by which diphenylsulphide might be formed.

The cyanide might well act as a reducing agent.

$$2NaSO_3C_6H_5 + 6NaCN = (C_6H_5)_2S + Na_2S + 6NaCNO$$

More sulphonate might react with the sodium sulphide thus formed:

$$2NaSO_2C_6H_5 + Na_2S = (C_6H_5)_2S + 2Na_2SO_3$$

Although the latter reaction has never been described, it would be in keeping with the behavior of the benzene sulphonates. Thus Spring and Krafft[10] prepared diphenylsulphide by the distillation of a mixture of sodium benzene sulphonate and phosphorus pentasulphide. Stadler[11] distilled sodium benzene sulphonate with potassium polysulphydrate and obtained thiophenol.

### The Gaseous Products

A large volume of gas was always evolved during distillation, a part of which condensed in the cooler portion of the receiver to form a sublimate of solid ammonium salts. The following compounds were identified in the gases evolved: ammonia, carbon dioxide, hydrogen sulphide, hydrocyanic acid, water.

In order to determine the composition of the gas quantitatively a run was made in which it was collected over a large volume of water, in which the greater part was soluble. The solution thus obtained and the gas over it were then analyzed for $NH_3$, $CO_2$, $H_2S$ and HCN. The water content of the gas could not be readily obtained. The results, expressed in per cent by weight, are given in Table I.

TABLE I. ANALYSIS OF EVOLVED GASES

Temperature 430°. Ratio cyanide : sulphonate :: 1 : 3.00 by weight.

| | Per Cent by Weight |
|---|---|
| $NH_3$ | 27.4 |
| $CO_2$ | 71.3 |
| $H_2S$ | 0.2 |
| HCN | 1.1 |
| | 100.0 |

### Summary and Discussion

It is evident from these experimental results that the formation of benzonitrile is accompanied by extensive side-reactions which give rise to a great variety of byproducts. These byproducts give some clue to the processes involved, which are obviously complex, but probably belong to two groups—namely, those due to the reducing action of sodium cyanide, and those due to the thermal decomposition of the organic compounds present.

The reducing power of cyanides at high temperatures is well known. This reducing action would result in the formation of diphenylsulphide according to the reactions already given. In this connection it is interesting to note that no sodium cyanide remained in the residue from the retort, even when a large excess was originally present.

The pyrogenic decomposition of sodium benzene sulphonate would result in the formation of water, hydrogen sulphide, carbon, and sodium carbonate or sulphide. It is true that pure sodium benzene sulphonate does not decompose appreciably at the temperature of the reaction, but Stenhouse has shown that different substances catalyze this decomposition in different ways, and it may well be that some of the other materials present exert a catalytic effect.

If water vapor were formed in this manner it would react immediately with the sodium cyanate formed from the sodium cyanide:

$$2NaCNO + 3H_2O = Na_2CO_3 + CO_2 + 2NH_3$$

This would account for the fact that large quantities of sodium carbonate, but only small amounts of sodium cyanate, were usually found in residue.

To sum up: In addition to the main reaction in which benzonitrile is formed, side reactions of two general types occur: (*a*) reduction of the sodium benzene sulphonate by the sodium cyanide, and (*b*) pyrogenic decomposition with the decomposition of the sodium cyanate formed in (*a*) and the consequent liberation of ammonia.

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*Part II will be published in a subsequent issue.*

[8] *Loc. cit.* See also Capelli, *Gazz. Chim. Ital.*, vol. 48, II, p. 109 (1918).
[9] Capelli, *loc. cit.*
[10] *Berichte*, vol. 7, p. 385 (1874).
[11] *Berichte*, vol. 17, p. 2080 (1884).

## Peruvian Copper Production for Four Years

The monthly production of copper by the Cerro de Pasco Copper Corporation of Cerro de Pasco, Peru, for the past four years was as follows: 72,675,032 lb. in 1917; 81,906,000 lb. in 1918; 58,124,000 lb. in 1919; 63,128,000 lb. in 1920. According to the foregoing figures, the production of copper in 1920 showed an increase of 5,004,000 lb. as compared with 1919. The production in 1920, however, was 18,778,000 lb. less than in 1918 and 9,547,032 lb. less than in 1917.

# The Vapor Compression System of Evaporation

## Description of the Autovapor Type of Evaporator Recently Introduced Into Practice in Europe—Comparison With Multiple Effect Evaporators Heated by Primary Heat, in Favor of New Design

BY GUSTAV CARLSSON
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BEFORE describing the vapor compression system of evaporation, the first great advance made in the evaporation of liquids might well be mentioned. Pecqueur in 1834 invented the multiple effect system, which resulted in an enormous saving for many industries in concentrating their products from aqueous solutions. The sugar industry adopted it, and as a matter of fact the improvements since that time are very closely connected with the development of that industry. Modern evaporators bear little resemblance to the original apparatus. As time went on other chemical industries have introduced multiple effect evaporators to concentrate the liquors containing valuable products in solutions.

Although multiple effect evaporation in the past has been one of the most important processes in the chemical industries, its weak points from an economical as well as a technical point of view must not be overlooked. In order to produce the necessary steam to operate it, fuel must be consumed. The cost of evaporation depends upon the price of this indispensable fuel. In order to utilize the heat at all economically several units must be put in series. With two units in series, we are able theoretically to evaporate 2 lb. of water per pound of steam, in a triple effect 3 lb. per

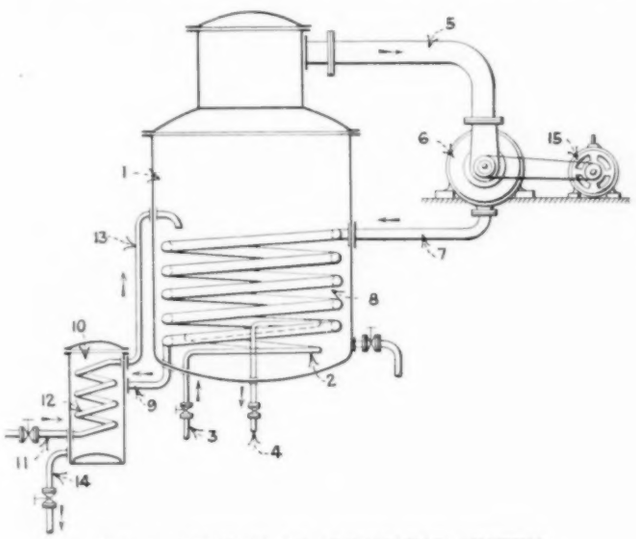



FIG. 1. SKETCH OF AUTOVAPOR SYSTEM

pound of steam, and so forth. In practice these figures of course do not hold, being 1.2 and 2 instead of 2 and 3, with apparatus having a capacity of 2,200 lb. of water evaporated per hour.

Many suggestions on new evaporation methods have been made and tried during recent years, but all of them have failed until quite recently. In 1918 a firm in Switzerland began manufacturing evaporators which are sold under the trade name of "Autovapor." They have been in use in a great number of plants in Europe. The results of operation indicate that it has some important advantages and that it will probably have continued and successful development in the chemical industry. To a large extent its progress is due to the development of the high-speed compressor, by which the problem of compressing the vapors has been solved in a very satisfactory manner.

In evaporating 1 lb. of water at 212 deg. F. and atmospheric pressure, about 970 B.t.u. is used, or practically one-tenth of the heat obtained from 1 lb. of coal. Instead of conducting the water vapor to the atmosphere, where it will be lost in space, we may compress it to about 3 atm., raising the temperature correspondingly to about 271 deg. F., and have useful energy available. The heat energy of the vapor has the energy of the work of compression added to it and if the compressed vapor is passed through a coil submerged in the liquor being evaporated, the vapor will condense, delivering its latent heat, whereupon more water will be evaporated from the liquor. Continuous evaporation is obtained by the addition of the mechanical energy required for compression.

### LINES OF DESIGN OF APPARATUS

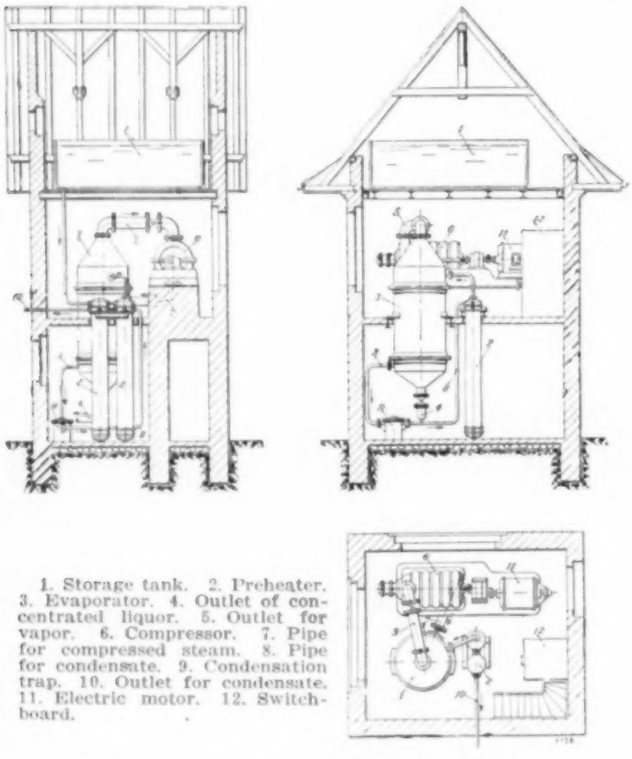
The liquid to be evaporated is placed in the evaporator, Fig. 1, and is heated to the boiling point by the steam coil 2. As soon as boiling has begun, the steam feed to the coil is cut down and the water vapor is drawn from 1 by pump 6, driven by the electric motor 15 and compressed through pipe 7 into coil 8. The compressed vapor condenses in the coils and delivers its heat of condensation and superheat, which from that time maintains ebullition in the evaporator. The condensate is discharged through pipe 9 into preheater 10, preheating the liquid charge entering the evaporator through coil 12 and the pipe 13, and then is emptied through pipe 14. The electric motor driving pump 6 consumes but a fractional part of the heat energy equivalent for evaporation. The evaporation of 1 lb. of water at atmospheric pressure requires about 970 B.t.u. To increase the pressure from 1 to 3 atm. and at the same time increase the temperature to about 271 deg. F., an amount of energy equivalent to 106 B.t.u. is required, measured at the shaft of the pump with the efficiency taken into account. This 106 B.t.u. is equivalent to slightly more than 10 per cent of the heat energy flowing through the pump and used in the evaporation. The best results are obtained with dilute solutions. When dealing with concentrated solutions, conditions are not so favorable, because the boiling points of the solutions are higher than those of the solvents.

One of the earliest types of Simplex-Autovapors—i.e., with single boiling pan and used in concentrating sodium hydroxide liquor—was thoroughly controlled by Prof. Stodola at the Institute of Technology in Zürich, Switzerland. The apparatus had been running for 1½ months and had not been cleaned prior to the test. The capacity was 2,200 lb. of water evaporated per hour. He stated the efficiency to be 36.2 to 37.7 lb. of water evaporated per kw.-hr., the liquid being concentrated from 7 deg. to 23 deg. Bé. This means that although the concentration was considerable, the evaporation is from 11.2 to 11.7 times that obtained by direct conversion of the electric current consumed into heat.

This result is particularly interesting because the apparatus was not thoroughly insulated against heat losses. The temperature of the feed liquor was about 68 deg. F. and the temperature of the condensate when leaving the system was 176 deg. F. Using a preheater, much better results should be obtained. The capacity of the apparatus was about 2,200 lb. of water evaporated per hour, consuming about 50 kw.-hr. In spite of the high concentration of the liquor, the condensate was very pure, containing but 0.002 g. NaOH per liter. This indicates that with this type of equipment distilled water is obtained with a degree of purity which an ordinary evaporator cannot deliver.

The arrangement of a small installation with a capacity of 2,200 lb. of water evaporated per hour is shown in Fig. 2.

In order to reduce heat losses, the different units



1. Storage tank. 2. Preheater. 3. Evaporator. 4. Outlet of concentrated liquor. 5. Outlet for vapor. 6. Compressor. 7. Pipe for compressed steam. 8. Pipe for condensate. 9. Condensation trap. 10. Outlet for condensate. 11. Electric motor. 12. Switchboard.

FIG. 2. SKETCH OF A PLANT INSTALLATION

of the apparatus are built closely together and the compressor and the motor are in the same room, because no corroding fumes were evolved there.

Among installations that have been erected for chemical purposes, some are used for concentrating sodium sulphite liquor containing more than 80 per cent water. The concentrated liquor is used as a binder for coal briquets, as a leather-filling substance, in producing alcohol, and so forth. This liquor is particularly adaptable, as the rise of the boiling point is small with increase of concentration, amounting to only from 5 to 8 deg. F. due to the high molecular weight of the dissolved substances. Most liquids that are evaporated, however, have much higher increments in their boiling point upon concentration, sodium hydroxide liquor being about 32 deg. F., saturated common salt solutions 16 deg. F. These increments of boiling temperature upon concentration must be taken into account when calculating the degree of compression of the vapor so that the increase in the temperature of the compressed vapor under the operation will compensate for the rise of the boiling point. In addition a temperature difference has to be established between the compressed vapor in the coil and the liquid to obtain a sufficient rate of heat transmission.

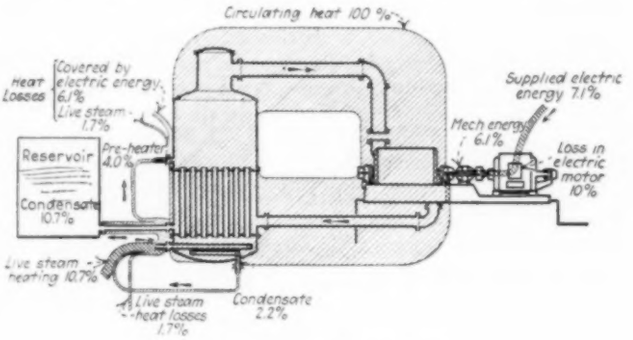



FIG. 3. ENERGY DIAGRAM

In the dye industry also apparatus mostly of the Simplex type have been installed, evaporating from 35.3 to 38.6 lb. of water per kw.-hr. continuously and they have in long runs produced liquor of 34 deg. Bé. It was necessary due to acid fumes to install the motor and the compressor in separate rooms. The capacity is about 2,760 lb. and the efficiency 35.3 to 39.8 lb. of water evaporated per kw.-hr. The liquid is evaporated to the same viscosity as sirup.

Returning to the test made by Prof. Stodola, the following data were obtained:

The rise in the boiling point was from 3.6 deg. to 12.6 deg. F. During a 5-hr. run 11,590 lb. of water was evaporated from the liquor, using 271.41 kw.-hr. to run the compressor and in addition 1,598 lb. of steam. The rate per hour gives: 2,320 lb. of water evaporated, using 54.28 kw.-hr. and 320 lb. of steam, or 42.6 lb. of water, evaporated per hour, neglecting the steam, and 37.7 lb., considering the steam used, respectively.

## Energy Consumption

Fig. 3 shows the results diagramatically. As a matter of fact, in the preheater only 4.0 per cent of the heat was recovered, while at the same time 10.7 per cent was removed by the condensate. In this case, however, the preheater was not enlarged, as the 10.7 per cent of heat in the hot condensate available could be used in other departments of the plant. As a result we might see that of the 12.4 per cent of steam added only 1.7 per cent has to be considered as a real loss due to insufficient heat insulation. We may now state that the test gave the following results: Using 271.41 kw.-hr. and 1,598 lb. of steam, 11,590 lb. of water was

evaporated from the liquor and in addition 13,235 lb. of distilled water was obtained at a temperature of 176 deg. F.

How to utilize the heat of the condensate has to be determined in each particular case. Being very pure, it may be used directly in the manufacturing process. In other cases an efficient preheater may be installed, and no doubt will pay for its investment. Summarily it may be seen that even such a small apparatus can be run economically.

Regarding the construction details of this evaporator, the following is quoted from the English patent: "The evaporator has vertical heating channels formed by annular hollow heating bodies, arranged concentrically one within the other. The channels are provided with scrapers, which extend from above and operate in a resilient manner on the vertical walls. The scrapers are of clamp shape, removable and mounted on a horizontal beam, which is rotated about a vertical axis."

### Comparison With Effect Types

The following figures are given for purposes of comparison of this method with a multiple effect system, based upon the results stated above and with a capacity of 2,200 lb. per hour. With a triple effect evaporator of this capacity 2 lb. of water may be evaporated per lb. of steam:

*a.* Using a vapor compression system evaporator, driven by electrical energy: Evaporating 2,200 of water, 51.6 kw.-hr. is necessary. Referring to previously stated results to cover heat losses: $\frac{1.7 \times 305}{12.4}$ = 41.7 lb. of steam is necessary. Assuming 8.5 lb. of steam per pound of coal, this corresponds to $\frac{41.7}{8.5}$ = 4.92 lb. of coal.

*b.* Using a triple effect evaporator: The following quantity of coal will be necessary: $\frac{2200}{2 \times 8.5} = 129.8$ lb. Assuming the running of the condensate pump requires 8 hp., the efficiency of which is 70 per cent, we get $\frac{8 \times 2545}{0.7 \times 9800}$ = 2.92 lb. of coal. Total, 132.73 lb. of coal. On the one hand we have 51.6 kw.-hr. and 4.92 lb. of coal. On the other hand 132.73 lb. of coal.

The significance of these figures for one year's run for plants having access to water power may be realized upon the following calculation, assuming coal cost at $10 per 2,000 lb. and the price per kw.-yr. at $30:

| | | | Total Cost |
|---|---|---|---|
| *a.* | 51.6 kw.-yr. @ $30 | $1,548 | |
| | 21.5 tons of coal @ $10 | 215 | $1,763 |
| *b.* | 580 tons of coal @ $10 | | 5,800 |
| | Saving by *a* vs. *b* | | $4,037 |

Using coal to produce the electrical energy, the vapor compression evaporator will prove its superiority to a triple-effect apparatus where byproduct steam is not available. Assuming a large steam turbine power station 1 kw.-hr. may be obtained with 10 lb. of steam and we get:

*a.* Compression Evaporator:

$\frac{51.6 \times 10}{8.5}$ = 60.8 lb. of coal to run the compressor.

Total: $\frac{4.92 \text{ lb. of coal for addition steam}}{65.72 \text{ lb. of coal}}$

In other words, 33.6 lb. of water evaporated per lb. of coal.

*b.* 1. Triple effect evaporator:
$2 \times 8.5 = 17$ lb. of water evaporated per lb. of coal.

2. Quadruple effect evaporator:
$3 \times 8.5 = 25.5$ lb. of water evaporated per lb. of coal.

The new system is thus superior even to a quadruple effect evaporator. In other words, the coals might in this case be better utilized in a power station than in direct heating.

More important, however, is the case when coal is used to produce high-pressure steam utilized in a power station, the exhaust steam being used for heating purposes. In this case we may substitute the necessary power for the corresponding heat energy, the mechanical efficiency of the motor taken into account. The thermal losses in compression increase the heat of vapors and are utilized in the system.

1. For 2,200 lb. of water evaporated per hour and requiring 51.6 kw.-hr. we use:

$\frac{51.6 \times 3420}{9800}$ = 18.2 lb. of coal

4.95 lb. of coal

Total: 23.15 lb. of coal

This gives an evaporation of 95 lb. of water per lb. of coal, being a very high efficiency.

2. On the other hand, using a high-pressure quadruple-effect evaporator, the efficiency of which is 3 lb. of water evaporated per pound of steam, we have: $\frac{2200}{8.5 \times 3}$ = 86.5 lb. of coal minus about 442 lb. of exhaust steam, corresponding to $\frac{442}{8.5}$ = 51.8 lb. of coal, the difference being 34.7 lb. of coal per 2,200 lb. of water evaporated, or $\frac{2200}{34.7}$ = 63.7 lb. of water evaporated per pound of coal.

From these calculations it is seen that the vapor compression system of evaporation is an economical one. In addition it has the advantage that the boiling point of the liquor may be regulated as is best in each particular case, although the high-pressure steam status is utilized, the evaporators running either under vacuum or high pressure.

It might be emphasized that all calculations given herewith are based upon the investigations by Prof. Stodola and are performed with a small installation. At greater capacities the efficiency of the compression should be greatly increased. Evaporating 2,200 lb. of water per hour, the efficiency was shown to be 19.3 lb. per kw.-hr., but having a capacity of 40,000 lb. per hour, the efficiency has proved to be 59.2 lb. of water evaporated per kw.-hr. As a matter of fact, dealing with solutions similar to water, the efficiency has proved to be 84 lb.

The construction of the vapor compression system evaporator may be varied according to the cost of the available electrical energy so as to get the most economical operation. Power being cheap, the compression may be high in order to decrease the heating surfaces. On the other hand, with high-priced electricity, it is possible to diminish the necessary power by using evaporators having larger heating surfaces.

# Dr. C. L. Alsberg Director of Stanford University Food Research Institute

DESPITE the fact that an adequate food supply for armies and for civilian populations always has been recognized as one of the vital factors in war, the Allied nations and the United States plunged into the late struggle without a vestige of preparation in that particular. There were no data, either statistical or historical. The food administrators had to work under the greatest handicaps, because no one ever had studied or had gathered information as to mass feeding. When Herbert Hoover met with the Allied food administrators during the war they each agreed to do all possible toward securing a systematic study of this problem so that it might be available in case of another emergency. Millions had been spent in studying ordnance, tactics and transportation, but Germany was the only country which had given any attention to the equally important matter of using food resources in a way that would help win a war.

When the war was over Mr. Hoover did not forget his promise to the other food administrators. He found that there was no prospect for the Government to take up at that time a work of that character, so he went to the Carnegie Corporation and interested it in financing such an undertaking. Then he went to the trustees of Stanford University and secured their promise of co-operation. As a result the Food Research Institute of Stanford University has been created and Dr. Carl Lucas Alsberg has been selected as one of its directors. There are to be two other directors. Painstaking care is being taken in the selection of these men. Mr. Hoover regards the work as essential to the national defense as is the furnishing of munitions to the Army or fuel to the Navy. Armies travel on their bellies, and doubly so do the civilian populations which stand behind those armies. The excitement at the front may relegate to a secondary importance an irregular or an inadequate food supply. In a battle-swept area or in a center of mobilization all are aware of the difficulties attendant upon food supply and irregularities are discounted. Not so in industrial centers far from the fighting line. With nothing spectacular or exciting to vary the monotony of the day's drudgery, irregularities in food have even a more important bearing on morale.

To produce food in sufficient quantities and to distribute it in a manner insuring the maximum of effective use was one of the great war problems which brought strikingly to the attention of the various nations the necessity for a study of the food problem as a whole. America is taking the initial step in this direction with the establishment of the Food Research Institute, none of the Allied countries having found the time as yet to start work along these lines. Holland, having seen the necessity, already has acted and has a study of this character well under headway.

The study in the United States is to be divided into three groups, each under the immediate charge of a director. One of the directors will be chosen for his qualifications to handle the economic and statistical features of the work. Another will supervise the activities pertaining to human nutrition, while the third will look after the industrial side of the question. It is this last angle of the work to which Dr. Alsberg has been assigned. No announcement has been made as to those who are being considered for the remaining directorships.

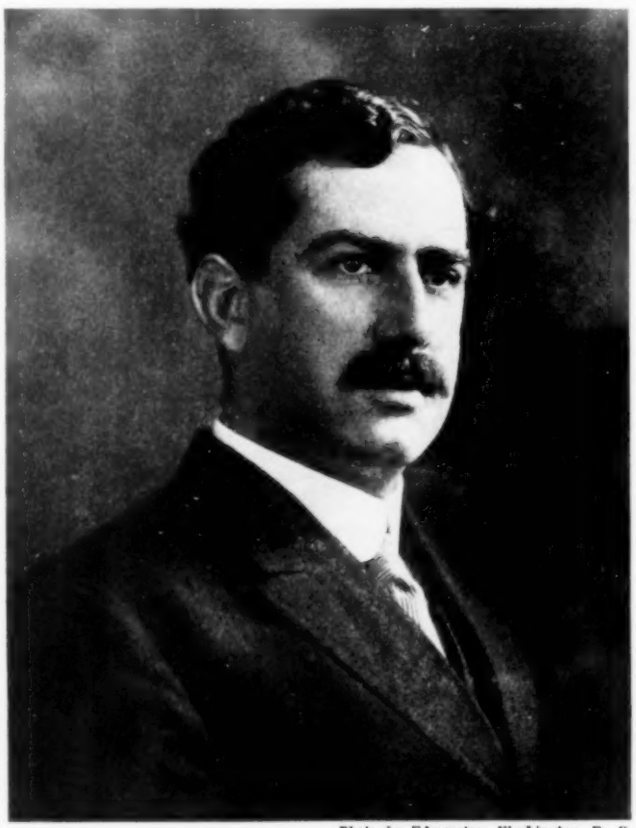


*Photo by Edmonston, Washington, D. C.*

DR. CARL L. ALSBERG

The Carnegie Corporation has agreed to finance the work for a period of from seven to ten years. The scale on which it is to be undertaken will be determined after three years. Great care will be exercised not to duplicate either work or equipment. Very general co-operation with existing laboratories is expected.

Dr. Alsberg plans to continue his work as chief of the Bureau of Chemistry of the United States Department of Agriculture until July 1. It probably will be Oct. 1 before he will be able to give his full time to his new duties.

Dr. Alsberg was born in New York City April 2, 1877. He was prepared for college by tutors and at preparatory schools, and entered Columbia College in 1892, receiving his A.B. in 1896. He then entered the medical department of Columbia University and received the degree of M.D. in 1900. In the same year he received his A.M. from Columbia University. While studying medicine he devoted considerable time to research with Dr. P. A. Levene, now chief of the chemical department of the Rockefeller Institute for Medical Research. In 1900 he did advanced work at the University of Strassburg in physiological chemistry, medicine and pharmacology. Later he worked in Berlin with Emil Fischer.

Late in 1902 Dr. Alsberg was appointed assistant in physiological chemistry at the Harvard Medical School. In 1905 he was made the head of the department. In 1908 he resigned to accept the position of chemical biologist in charge of the poisonous plant laboratory of the Bureau of Plant Industry. On Dec. 16, 1912, he succeeded Dr. Harvey W. Wiley as Chief of the Bureau of Chemistry.

# Miscellaneous Alloys of Nickel

## Principal Data on Binary Alloy Systems With Nickel as One Constituent — Use of Nickel in Bronzes and Light Aluminum Alloys—Composition and Electrical Characteristics of Many Special Resistance Alloys—Analyses of Complex Alloys for Various Minor Uses

BY PAUL D. MERICA
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### EQUILIBRIUM OF BINARY ALLOYS OF NICKEL

THE constitution of most of the important binary alloy series with nickel has been investigated fairly completely and the principal results of the investigations of the systems forming one or more compounds are given in tabular form in Table I. It is observed that nickel has a strong tendency to form solid solutions with other metals, either of limited compositions or in all proportions. Structurally speaking, it is perhaps mainly for this reason that the metal forms a constituent of so many commercially useful ferrous and non-ferrous alloys. Thus nickel and any one of the following metals are soluble in all proportions in the solid state: Chromium, cobalt, copper, iron, manganese, palladium and platinum. A 60: 40 nickel: chromium alloy has the minimum melting point of that series at 1,290 deg. C.; a 70: 30 nickel: iron alloy melts at 1,425 deg. C., the minimum for that series, and correspondingly, a 44: 56 nickel: manganese alloy melts at 1,000 deg. C.

Gold and nickel form a simple eutectiferous series; the eutectic analyzes 27 per cent Ni and melts at 950 deg. C., and is composed of two conjugate solid solutions containing approximately 16 per cent gold and 6 per cent nickel respectively.

Table II gives the principal data concerning three binary systems having limited solubility in the liquid state.

### ACID-RESISTING ALLOYS

Many nickel alloys display an even greater resistance to acid corrosion than nickel itself. The acid-resisting properties of Monel metal have already been noted by the author in CHEMICAL AND METALLURGICAL ENGINEERING, vol. 24, p. 291 (Feb. 16, 1921). It may be remembered that Monel metal does not resist the action of nitric acid.

Chromium:nickel alloys are acid-resisting and are used for dipping baskets and other articles exposed to acid corrosion. The following results of tests communicated by the Driver-Harris Co. indicate the degree of resistance to acid corrosion afforded by the composition used for Ni-chrome castings. The samples, of 125 g. weight, were immersed in 300 c.c. cold acid for 200 hours.

TABLE II. BINARY ALLOYS OF NICKEL HAVING LIMITED MISCIBILITY IN THE LIQUID STATE

| Nickel and | Temperature of Beginning Melting: Temperature Deg. C. | Temperature of Beginning Melting: Composition per Cent Ni | Solubility in Solid State: Second Constituent in Nickel per Cent | Solubility in Solid State: Ni in Second Constituent per Cent |
|---|---|---|---|---|
| Lead | 326 | 97–0 | 3 | 0.7 |
| Silver | 961 | 100–0 | .. | .... |
| Thallium | 320 | 97–0 | 3 | 0 |

| Acid | Loss in Weight in per Cent of Weight (125 g.) per Day: 20% Acid | 30% Acid | 50% Acid | 60% Acid |
|---|---|---|---|---|
| Sulphuric | 0.009 | 0.005 | 0.005 | 0.005 |
| Hydrochloric | 0.14 | 0.34 | ..... | ..... |
| Nitric | 0.08 | 0.13 | 0.22 | 0.30 |

Prof. S. W. Parr[1] has developed an alloy, which he calls Ilium, of the following composition:

| | | | | | |
|---|---|---|---|---|---|
| Copper | 6.42 | Tungsten | 2.13 | Iron | 0.76 |
| Manganese | 0.98 | Nickel | 60.65 | Chromium | 21.07 |
| Silicon | 1.04 | Aluminum | 1.09 | Molybdenum | 4.67 |

This alloy has been applied by him with success in the construction of combustion chambers of calorim-

[1] *Trans.*, Am. Inst. Metals, vol. 9, p. 211 (1915).

TABLE I. BINARY ALLOYS OF NICKEL IN WHICH THE TWO METALS FORM ONE OR MORE COMPOUNDS

| Nickel and | Compounds Formed | Nickel-Rich Alloys: Compound | Solubility of compound* | Eutectic: Temperature, Deg. C | Eutectic: Composition | Nickel-Poor Alloys: Compound | Solubility of compound at eutectic temperature† | Eutectic: Temperature, Deg. C | Eutectic: Composition† |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | NiAl; $NiAl_2$; $NiAl_3$ | NiAl | 14 | (*p*) 1,370 | 13 | $NiAl_3$ | 0(?) | 630 | 7 |
| Antimony | $SbNi_2$; $Sb_2Ni_3$; SbNi | $Sb_2Ni_3$ | 7.5 | 1,100 | 35 | SbNi | 0 | 612 | 4 |
| Arsenic | $NiAs_2$; $Ni_5As_2$; $Ni_3As_2$; NiAs | $Ni_5As_2$ | 5.5 | 898 | 28 | ..... | ... | ... | .. |
| Bismuth | NiBi; $NiBi_3$ | NiBi | 2 | (*p*) 655 | ..... | $NiBi_3$ | 0 | 272 | 0 |
| Boron | ..... | ..... | .... | ..... | ..... | ..... | ... | ... | .. |
| Cadmium | $NiCd_4$ | ..... | .... | ..... | ..... | $NiCd_4$ | 0 | 321 | 0 |
| Carbon | ..... | ..... | .... | ..... | ..... | ..... | ... | ... | .. |
| Magnesium | $Ni_2Mg$; $NiMg_2$ | $Ni_2Mg$ | 0 | 1,082 | 12 | $NiMg_2$ | 0 | 512 | 32 |
| Molybdenum | MoNi | MoNi | 33 | 1300 | 49 | ..... | ... | ... | .. |
| Phosphorus | $Ni_3P$; $Ni_5P_2$; $Ni_2P$ | $Ni_5P_2$ | 0 | 880 | 12 | ..... | ... | ... | .. |
| Selenium | ..... | ..... | .... | ..... | ..... | ..... | ... | ... | .. |
| Silicon | $Ni_3Si$; $Ni_2Si$; $Ni_3Si_2$; NiSi | $Ni_3Si$ | 6 | 1,153 | 10.6 | ..... | ... | ... | .. |
| Sulphur | $Ni_3S_2$; NiS | $Ni_3S_2$ | 0.5 | 644 | 23 | ..... | ... | ... | .. |
| Tellurium | ..... | ..... | .... | ..... | ..... | ..... | ... | ... | .. |
| Tin | $Ni_4Sn$; $Ni_3Sn$; $Ni_3Sn_2$ | $Ni_3Sn$ | 15 | 1,135 | 33 | $Ni_3Sn_2$ | 0 | 229 | 1(?) |
| Zinc | NiZn; $NiZn_3$ | NiZn | 30(?) | (*p*) 1,035 | .... | $NiZn_3$ | 0 | 419 | 0 |

(*p*) Peritectic. * In per cent of second metal forming system of alloys with nickel. † In per cent of nickel.

eters, as it is practically unattacked by 25 per cent nitric acid. The alloy may be cast and machined, although with some difficulty; it has a tensile strength of about 50,000 lb. per sq.in.

Tungsten:nickel alloys have been prepared by Irmann[2] and their resistance to the action of sulphuric acid studied. He discovered that the resistance of nickel to the action of 65 per cent acid, which itself is considerable, is increased fourfold by the addition of 5 per cent of tungsten and twelvefold by the addition of 10 per cent. Alloys containing under 18 per cent have sufficient ductility that they may be formed into sheets.

Fairlie[3] has reported some tests of nickel:lead alloys for acid-resisting purposes. Alloys containing from 1 to 3 per cent of nickel and remainder lead were more resistant to the action of 50 to 60 deg. Bé. sulphuric acid, both hot and cold, than pure lead, and had a tensile strength of about 3,000 lb. per sq.in., about 30 per cent greater than that of lead. The antimony:lead alloys were much harder and stronger and although resistant to the action of cold were not resistant to the action of hot acid.

Some of his results are reproduced in Table III.

TABLE III. ACID RESISTANCE OF NICKEL: LEAD ALLOYS

| Composition | Elongation in 0.5 In., per Cent | Tensile Strength in Lb. per Sq.In. | Loss in Weight in 50 Pé. $H_2SO_4$ | | Loss in Weight in 50 Pé. $H_2SO_4$ | |
|---|---|---|---|---|---|---|
| | | | Cold Loss in One Week, per Cent | Hot (184°C.) Loss in One Week, per Cent | Cold Loss in One Week, per Cent | Hot (184° C.) Loss in One Week, per Cent |
| 100% Pb | 110 | 2,360 | 0.014 | 0.357 | 0.078 | 0.419 |
| 80% Pb, 20% Sb | 5 | 7,540 | 0.015 | 2.425 | 0.091 | 5.817 |
| 99% Pb, 1% Ni | 74 | 3,170 | 0.009 | 0.190 | 0.035 | 0.391 |
| 96½% Pb, 3½% Ni | 32 | 3,260 | 0.021 | 0.134 | 0.057 | 0.199 |

The disadvantages of the nickel:lead alloys are their low strength and difficulty of preparation, due to the great difference between the melting points of the components.

Clamer has patented ferronickel alloys for production on non-corrodible sheets, rods, etc. These contain approximately 25 to 50 per cent nickel, 5 to 20 per cent copper, remainder iron.

An alloy[4] of 30 per cent tantalum and 70 per cent nickel is reported to be resistant to the action of boiling aqua regia. Siemens-Halske has patented similar compositions for this purpose.

## Nickel in Bronzes

Nickel is used to some extent, particularly abroad, as a component of brasses[5] and of aluminum bronzes, to which it appears to impart desirable properties. Parker[6] has pointed out the desirability of studying the possibilities of these alloys for the construction of high-speed turbine blading for superheated steam, and mentions several compositions which are in commercial use in Great Britain. These are as follows:

| | A | B | C |
|---|---|---|---|
| Copper | 82.07 | 79.63 | 79.0 |
| Aluminum | 2.54 | 9.77 | 11.5 |
| Nickel | 14.64 | 4.13 | 5.0 |
| Manganese | nil | 0.94 | nil |
| Zinc | 0.68 | nil | nil |
| Iron | trace | 4.80 | 4.5 |
| Silicon | 0.04 | 0.14 | .... |

[2] *Metall u. Erz*, vol. 5, p. 21, (1917).
[3] *Metal Ind.*, vol. 3, p. 64, (1911).
[4] *Metall u. Erz* (1918), p. 22.
[5] Guillet, CHEM. & MET. ENG., vol. 24, p. 261 (Feb. 9, 1921).
[6] *J. Inst. Metals*, vol. 14, p. 25 (1915).

Bronzes of similar composition containing aluminum and nickel have also been produced commercially as substitutes for nickel silver under such names as aluminum silver and minargent. They have a fine white color and will take a good polish.

Read and Greaves[7] have contributed results of extensive tests of aluminum:nickel bronzes of this type. These alloys were found to forge and roll satisfactorily and to have good mechanical properties, the hardness increasing with the nickel content. Table IV contains the results of some of their tensile tests on annealed

TABLE IV. TENSILE PROPERTIES OF NICKEL: ALUMINUM COPPER ALLOYS

| Chemical Composition | | | Tensile Properties | | | |
|---|---|---|---|---|---|---|
| Per Cent Cu | Per Cent Ni | Per Cent Al | Yield Point | Tensile Strength, Lb. per Sq.In. | Elongation in 2 In., per Cent | Reduction of Area, per Cent |
| 89.94 | .... | 10.06 | 32,200 | 57,500 | 9.0 | 10.4 |
| 87.66 | 2.46 | 9.88 | 40,500 | 71,500 | 12.3 | 13.0 |
| 85.11 | 4.95 | 9.94 | 40,400 | 77,400 | 16.2 | 17.4 |
| 82.82 | 7.48 | 9.70 | 42,100 | 87,000 | 13.1 | 15.1 |
| 94.98 | .... | 5.02 | 11,600 | 49,600 | 82.5 | 78.9 |
| 93.96 | 0.94 | 5.10 | 11,800 | 51,000 | 94.6 | 76.1 |
| 92.68 | 2.38 | 4.94 | 12,300 | 51,300 | 90.2 | 71.0 |
| 89.84 | 4.84 | 5.32 | 21,100 | 57,200 | 70.0 | 60.2 |
| 87.48 | 7.31 | 5.21 | 53,700 | 87,400 | 25.6 | 26.8 |

alloys rolled from 2¼-in. ingots. Corrosion tests in fresh and sea water carried out by these investigators indicated that the presence of nickel in aluminum bronzes decreases markedly the corrosion in sea water; it does not seem to affect corrosion in fresh water in any definite manner, as shown in Table V.

The properties of light aluminum alloys containing nickel have been studied by Read and Greaves[7], Merica, Waltenberg and Finn[8] and Merica and Karr,[9] and it seems to have been demonstrated that nickel in aluminum up to 4 per cent will produce an alloy which will roll and work very readily and have quite satisfactory mechanical properties. Thus an alloy containing 3.9

TABLE V. CORROSION TESTS OF ROLLED AND ANNEALED NICKEL: ALUMINUM: COPPER ALLOYS

| Chemical Composition | | | Corrosion Loss in Weight in Lb. per Sq.Ft. per Month | |
|---|---|---|---|---|
| Per Cent Cu | Per Cent Ni | Per Cent Al | Sea Water | Fresh Water |
| 89.94 | .... | 10.06 | 0.00091 | 0.00009 |
| 89.55 | 0.97 | 9.48 | 0.00022 | 0.00006 |
| 85.15 | 4.94 | 9.91 | 0.00012 | 0.00011 |
| 80.13 | 9.98 | 9.81 | 0.00009 | 0.00009 |
| 94.98 | .... | 5.02 | 0.00031 | 0.00006 |
| 94.04 | 0.92 | 5.04 | 0.00031 | 0.00008 |
| 90.09 | 4.90 | 5.01 | 0.00012 | 0.00007 |
| 85.08 | 10.07 | 4.85 | 0.00002 | 0.00012 |

per cent of nickel in the form of rolled and annealed sheet possessed the following tensile properties:

| | |
|---|---|
| Tensile strength | 20,200 lb. per sq.in. |
| Elongation in 2 in | 24 per cent |

It does not appear that light alloys containing nickel are as strong, hard and resistant to corrosion as those which have been hardened with copper, manganese or zinc in similar amounts and would therefore not give much promise of replacing present commercial wrought light alloys of the copper:aluminum, copper:magnesium:aluminum or zinc:aluminum type.

Promising results have been obtained, however, with the addition of from 1 to 2 per cent of nickel in aluminum casting-alloys containing also from 2 to 3 per cent of copper, and there seem to be some possibilities of development in this direction. Thus Merica and Karr have obtained the following tensile test results with a

[7] *J. Inst. Metals*, vol. 13, p. 100 (1915); vol. 11, p. 169 (1914).
[8] Bu. Standards Tech. Paper 132.
[9] Bu. Standards Tech. Paper 139.

TABLE VI. THERMO-ELECTROMOTIVE FORCE OF REPRESENTATIVE COUPLES. COLD-JUNCTION TEMPERATURE, 0 DEG. C.

| Copper-Constantan | | Iron-Constantan | | Chromel-Alumel | |
|---|---|---|---|---|---|
| Emf., Millivolts | Temp., Deg. C. | Emf., Millivolts | Temp., Deg. C. | Emf., Millivolts | Temp., Deg. C. |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 25 | 5 | 95 | 5 | 122 |
| 2 | 49 | 10 | 186 | 10 | 243 |
| 3 | 72 | 15 | 277 | 15 | 363 |
| 4 | 94 | 20 | 367 | 20 | 482 |
| 5 | 115 | 25 | 457 | 25 | 601 |
| 6 | 136 | 30 | 546 | 30 | 721 |
| 7 | 156 | 35 | 632 | 35 | 844 |
| 8 | 175 | 40 | 713 | 40 | 970 |
| 9 | 194 | 45 | 792 | 45 | 1,100 |
| 10 | 213 | 50 | 871 | .. | .... |
| 11 | 232 | 55 | 950 | .. | .... |
| 12 | 250 | 60 | 1,030 | .. | .... |
| 13 | 268 | .. | ... | .. | .... |
| 14 | 285 | .. | ... | .. | .... |
| 15 | 302 | .. | ... | .. | .... |
| 16 | 319 | .. | ... | .. | .... |
| 17 | 336 | .. | ... | .. | .... |
| 18 | 353 | .. | ... | .. | .... |

sand-cast alloy containing 3 per cent copper, 0.8 per cent manganese and 1.5 per cent nickel:

| | |
|---|---|
| Tensile strength | 24,000 to 25,000 lb. per sq.in. |
| Proportional limit | 6,000 to 7,000 lb. per sq.in. |
| Elongation in 2 in | 8.5 per cent |

In this connection it might be noted that nickel is used in the casting alloy called magnalite, and in certain varieties of magnalium produced abroad; these will contain from 1 to 2 per cent of nickel.

Nickel has been substituted for a portion of the tin in government bronzes with attractive results (Burgess and Woodward[10]); these investigators give the following results of tensile tests of castings:

| | Tensile Strength | Yield Point | Elongation | Reduction of Area |
|---|---|---|---|---|
| 88 Cu, 5 Sn, 5 Ni, 2 Zn... | 40,700 | 13,100 | 31.8 | 28.0 |
| 89 Cu, 4 Sn, 4 Ni, 3 Zn... | 39,700 | 11,500 | 31.2 | 31.2 |

These results may be compared with advantage to the American Society for Testing Materials specifications for government bronze (88 Cu, 10 Sn, 2 Zn) as follows:

| | |
|---|---|
| Tensile strength | 30,000 lb. per sq. in. |
| Elongation in 2 in | 14 per cent |

The proposal has also been made by McKinney[11] to substitute nickel for a portion of the copper in 88:10:2 by using some cupronickel scrap in making the alloy.

## Alloys for Electrical Purposes

The chief electrical uses for alloys containing nickel for the construction of pyrometer thermocouples and the construction of rheostats and electrical heating devices. The use of an alloy containing from 3 to 5 per

[10] *Trans.*, Am. Inst. Mining Eng., vol. 58, p. 175 (1919).
[11] *Bull.*, Am. Inst. Mining Eng., December, 1919, p. 3185.

TABLE VII. COMPOSITION AND PROPERTIES OF ELECTRICAL ALLOYS

| Name of Alloy | Form in Which Produced | Chemical Composition | | | | | Electrical Resistivity: Resistivity in Microhm, Cm. | Electrical Resistivity: Temperature Coefficient, per Deg. C. | Electrical Resistivity: Resistivity in Ohm, Mil-Ft. at 75 Deg. F. | Tensile Strength, Lb. per Sq.In. | | Density | Melting Point or Range, Deg. C | Recommended Max. Working Temp., Deg. C | Thermal Expansivity, Deg. C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ni | Cr | Cu | Fe | Mn | | | | | | | | | |
| **A—Nickel: Chromium Alloys** | | | | | | | | | | | | | | | |
| Nichrome (*a*) | Wire, ribbon | 60 | 12 | ..... | 26 | 2 | 109.5 | 0.00017 | 660 | 100,000 | | 8.15 | ..... | 1,000 | 0.000164 |
| Nichrome (*a*) | Castings (*f*) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 50,000 to 55,000 | | 8.15 | ..... | 1,100 | 0.000121 |
| Nichrome 2(*a*) | Wire, ribbon | 66 | 22 | ..... | 10 | 2 | 110 to 113 | 0.00017 | 660 to 680 | ..... | | 8.02 | ..... | 1,100 | ..... |
| Kromore (*a*) | Wire, ribbon | 85 | 15 | ..... | ..... | ..... | 96.4-101.5 | 0.00024 | 580 to 610 | ..... | | ..... | ..... | ..... | ..... |
| Chromel A (*c*) | Wire, ribbon, catgs | 80 | 20 | ..... | ..... | ..... | 103 | 0.00011 | 620 | ..... | | 8.3 | ..... | 1,100 | ..... |
| Chromel B (*c*) | Wire, ribbon | 85 | 15 | ..... | ..... | ..... | 89 | 0.00011 | 535 | ..... | | 8.46 | ..... | ..... | ..... |
| Chromel C (*c*) | Wire, ribbon | 64 | 11 | ..... | 25 | ..... | 108 | 0.00018 | 650 | ..... | | 8.16 | ..... | ..... | ..... |
| Calorite | ..... | 65 | 12 | ..... | 15 | 8 | 110 | ..... | 662 | ..... | | ..... | ..... | ..... | ..... |
| Calido (*b*) | Wire, ribbon | 65 | 12 | ..... | 23 | ..... | 103 | 0.00036 | 620 | Hard, | 160,000 | ..... | ..... | ..... | ..... |
| | | | | | | | | | | Soft, | 80,000 | 8.15 | 1,530 | 1,000 | 0.000016 |
| Excello | ..... | 85 | 14 | .. | 0.5 | 0.5 | 92 | ..... | 554 | ..... | | ..... | ..... | ..... | ..... |
| Rayo (*b*) | Wire, ribbon | 85 | 15 | ..... | ..... | ..... | 95.7 | 0.00018 | 575 | Hard, | 160,000 | ..... | ..... | ..... | ..... |
| | | | | | | | | | | Soft, | 80,000 | 8.05 | 1,530 | 1,100 | 0.000015 |
| Tophet | ..... | 61 | 10 | ..... | 26 | 3 | 107 | ..... | 644 | ..... | | ..... | ..... | ..... | ..... |
| Chromel (*c*) | ..... | 89 | 10 | ..... | 1 | ..... | ..... | ..... | ..... | ..... | | ..... | ..... | ..... | ..... |
| Nichroloy 1 (*d*) | ..... | 75 | 16 | ..... | 7 to 9 | 3 | ..... | ..... | ..... | ..... | | ..... | ..... | ..... | ..... |
| Nichroloy 2 (*d*) | ..... | 40 | 7 | ..... | 50 | 3 | ..... | ..... | ..... | ..... | | ..... | ..... | ..... | ..... |
| Nichroloy (*d*) | Castings (*g*) | 23 | 20 | ..... | 50 | 1 | ..... | ..... | ..... | ..... | | ..... | ..... | 1,100 | ..... |
| Kromax | ..... | 80 | 20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | | ..... | ..... | ..... | ..... |
| **B—Ferronickel Alloys** | | | | | | | | | | | | | | | |
| Climax (*a*) | Wire, ribbon | 25 | ..... | ..... | 75 | ..... | 83.1 | 0.00098 | 500 | ..... | | 8.14 | ..... | ..... | 0.0000171 |
| No. 193 (*a*) | Wire, ribbon | 30 | 2 | ..... | 68 | ..... | 87.2 | 0.0007 | 525 | ..... | | 8.14 | ..... | ..... | 0.0000171 |
| Comet (*b*) | Wire, ribbon | 32 | 3 | ..... | bal. | ..... | 87.0 | 0.0007 | 525 | Hard, | 150,000 | 8.15 | 1,510 | 600 | 0.000016 |
| Phenix (*b*) | Wire, ribbon | 25 | ..... | ..... | bal. | ..... | 83.1 | 0.0011 | 500 | Soft, | 70,000 | 8.10 | 1,510 | 600 | 0.000017 |
| Ferrozoid (*e*) | ..... | ..... | ..... | ..... | ..... | ..... | 84.0 | ..... | 506 | Hard, | 140,000 | ..... | ..... | ..... | ..... |
| Kruppin (*e*) | ..... | 28 | ..... | ..... | bal. | ..... | 85.0 | ..... | 512 | Soft, | 70,000 | ..... | ..... | ..... | ..... |
| Vestalin (*e*) | ..... | ..... | ..... | ..... | ..... | ..... | 85.1 | ..... | 512 | ..... | | ..... | ..... | ..... | ..... |
| **C—Nickel: Copper Alloys** | | | | | | | | | | | | | | | |
| Advance (*a*) | ..... | 44 to 46 | ..... | bal. | ..... | 0.75 to 1.25 | 48.9 | nil | 294 | ..... | | 8.9 | .... | ..... | 0.0000144 |
| Ideal (*b*) | Wire, ribbon | 45 | ..... | 55 | ..... | ..... | 49.2 | 0.000005 | 296 | Hard, | 115,000 | 8.9 | 1,210 | 500 | 0.000014 |
| | | | | | | | | | | Soft, | 60,000 | | | | |
| Lucero (*b*) | Wire, ribbon | 65 | ..... | 30 | ..... | bal. | 46.5 | 0.0007 | 280 | Hard, | 140,000 | 8.9 | 1,350 | 600 | 0.000014 |
| | | | | | | | | | | Soft, | 65,000 | | | | |
| Nickelin (*e*) | ..... | 31 to 32 | ..... | 55 to 68 | Zn 6 to 13 | | 43.0 | ..... | 258 | ..... | | ..... | ..... | ..... | ..... |
| Ferry (*e*) | ..... | ..... | ..... | ..... | ..... | ..... | 47.2 | ..... | 284 | ..... | | ..... | ..... | ..... | ..... |
| Constantan | ..... | 40 to 55 | ..... | bal. | ..... | ..... | 48 to 50 | ..... | 295 to 300 | ..... | | ..... | ..... | ..... | ..... |
| Eureka (*e*) | Similar to Constantan | ..... | ..... | ..... | ..... | ..... | 50.2 | ..... | 302 | ..... | | ..... | ..... | ..... | ..... |
| Monel | ..... | 67 | ..... | 28 | —balance— | | 42.5 | 0.0019 | 256 | ..... | | ..... | ..... | ..... | ..... |
| **D—Nickel: Silver Alloys** | | | | | | | | | | | | | | | |
| 18% (*a*) | ..... | ..... | ..... | ..... | ..... | ..... | 36.3 | 0.00030 | 218 | ..... | | 8.5 | ..... | ..... | ..... |
| 7% (*c*) | ..... | ..... | ..... | ..... | ..... | ..... | 18.0 | ..... | 108 | ..... | | ..... | ..... | ..... | ..... |
| 10% (*c*) | ..... | ..... | ..... | ..... | ..... | ..... | 21.0 | ..... | 126 | ..... | | ..... | ..... | ..... | ..... |
| 20% (*c*) | ..... | ..... | ..... | ..... | ..... | ..... | 29.0 | ..... | 174 | ..... | | ..... | ..... | ..... | ..... |
| 30% (*c*) | ..... | ..... | ..... | ..... | ..... | ..... | 40.2 | ..... | 241 | ..... | | ..... | ..... | ..... | ..... |
| Platinoid | ..... | ..... | ..... | ..... | ..... | ..... | 41.0 | ..... | 246 | ..... | | ..... | ..... | ..... | ..... |
| Rheotan II | ..... | 25 | ..... | 52.5 | 5 | 18 Zn | ..... | ..... | ..... | ..... | | ..... | ..... | ..... | ..... |
| **E—Miscellaneous Alloys** | | | | | | | | | | | | | | | |
| Alumel | ..... | 94 | $Si_1$ | $Al_2$ | 0.5 | 2.5 | ..... | ..... | ..... | ..... | | ..... | ..... | ..... | ..... |
| Manganin | ..... | 2 to 16 | ..... | 50 to 85 | ..... | 12 to 30 | 42 to 48 | 0.00001 | 250 to 290 | ..... | | ..... | ..... | ..... | ..... |
| Tarnac (*e*) | Cupro-manganese | ..... | ..... | ..... | ..... | ..... | 41.0 | ..... | 246 | ..... | | ..... | ..... | ..... | ..... |
| Resistin (*e*) | Cupro-manganese | ..... | ..... | 84 to 86 | 2 | 11 to 13 | 50.2 | ..... | 302 | ..... | | ..... | ..... | ..... | ..... |
| Magno (*b*) | Wire, ribbon | 95 | ..... | ..... | ..... | 5 | 86.4 | ..... | 520 | Hard, | 140,000 | ..... | ..... | 800 | ..... |
| | | | | | | | | | | Soft, | 65,000 | .... | 1,400 | ..... | 0.000014 |

(*a*) Data from Driver-Harris Co. (*b*) Data from Electrical Alloys Co. (*c*) Data from Hoskins Manufacturing Co. (*d*) Data from Hiram Walker & Sons Co. (*e*) Law "Alloys and Their Industrial Application." (*f*) Brinell hardness 179. Specific heat, 0.111 cal., per g. at 100 deg. C. Thermal conductivity, 0.0341 cal. per sec. per cm. (*g*) Also contains 0.5 Si, 0.5 Al, 1.0 C, 1.0 V.

TABLE VIII. MISCELLANEOUS ALLOYS CONTAINING NICKEL

| Name of Alloy | Chemical Compositions | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Ni | Cu | Fe | Zn | Mn | Al | Pb | Sn | |
| Aphtit | 20–21 | 70–75 | ..... | 5 2–2 2 | ..... | ..... | ..... | ..... | Cd 4.5-1.8. |
| Ajax metal | 25–50 | 5–20 | 30–70 | ..... | ..... | ..... | ..... | ..... | Bearing metal, gun mountings. |
| Aluminum—nickel | 76.4 | ..... | ..... | ..... | ..... | 23 6 | ..... | 20 | Ag 10. |
| Aluminum—silver | 20 | 57 | 20 | ..... | ..... | 3 | ..... | ..... | |
| Aluminum—wire (B) | 1.3 | 1 | ..... | ..... | ..... | 97 7 | ..... | ..... | |
| Argozie | 14 | 54 | ..... | 28 | ..... | ..... | 2 | 2 | Castings. |
| Ashberry metal | 1–3 | 2–3 | ..... | 1–3 | ..... | ..... | ..... | 78–80 | Sb 14–20. Tableware. |
| Aterite | 12–18 | 55–60 | 6–10 | 13–20 | ..... | ..... | 1–2 5 | ..... | Valves and valve parts. |
| Bario metal | 90 | ..... | ..... | ..... | ..... | W1 22 | Si 0 2 | 9 Cr | 4.25 Heat and acid-resisting alloy. |
| Bearing metal | 10.4 | ..... | ..... | ..... | ..... | ..... | ..... | 83 3 | W 6 3. For high speeds. |
| Bismuth brass | 31 | 47 | ..... | 21 | ..... | ..... | 1 | ..... | Bi 1. |
| Bismuth bronze | 24 | 25 | ..... | ..... | ..... | ..... | ..... | ..... | Sb 50, Bi 1. |
| Bismuth bronze | 10 | 53 | ..... | 20 | ..... | 1 | ..... | 15 | Bi 1. |
| Bismuth bronze | 32 5 | 45 | ..... | 21 5 | ..... | ..... | ..... | 16 | Bi 1. |
| Chromax bronze | 15 2 | 66.7 | ..... | 12 1 | ..... | 3 0 | ..... | ..... | Cr 3.0. Can be rolled. T.S. 79,000 lbs. per sq.in. 3% elongation. |
| Cooperite | 80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | W 14, Zr 6. Cutting tools. |
| Cuniloy | 65 | 25 | ..... | ..... | 3½ | ..... | 1 | ..... | Resistance to corrosion and alkalis. |
| Cufenium | 22 | 72 | 6 | ..... | ..... | ..... | ..... | ..... | Knives, forks, spoons. |
| English nickel (complex) | 2 | 2 | ..... | ..... | 1 | ..... | ..... | 87 | Bi 0.5, W 1.5, Sb 6. |
| Illium | 60.6 | 6.4 | ..... | ..... | ..... | ..... | ..... | ..... | Mo 4.6, Cr 21, Acid resistance. |
| Invar | 37 | ..... | 63 | ..... | ..... | ..... | ..... | ..... | 37% nickel steel. |
| Machine bronze | 25 | 50–90 | ..... | 0 30 | ..... | ..... | 0–8 | 0–30 | |
| Machine bronze | 25 | 50 | ..... | ..... | ..... | ..... | ..... | 25 | |
| Manganin | 8–10 | 80 | ..... | ..... | 10–12 | ..... | ..... | ..... | See p. 651. |
| Minargent | 39.77 | 56.82 | ..... | ..... | ..... | 0 57 | ..... | ..... | W 2.84. |
| Minargent | 32 | 46 | ..... | ..... | ..... | ..... | 22 | ..... | |
| Mira metal | 0 24 | 74.7 | 0 43 | 0 62 | ..... | ..... | 16 3 | 0 91 | Sb 6.8. For cocks, pipes, etc., to resist acid corrosion. |
| Neogen | 12 | 58 | ..... | 27 | ..... | 0 5 | ..... | 2 | |
| Nickel aluminum bronze | 10 | 88 | ..... | ..... | ..... | 2 | ..... | | |
| Nickel aluminum bronze | 40 | 10 | ..... | ..... | ..... | 30 | ..... | 20 | |
| Nickel bronze | 30 | 86 | ..... | ..... | ..... | ..... | ..... | 11 | |
| Nickel bronze | 20 | 60 | ..... | 12 | ..... | ..... | ..... | 8 | |
| Nickel bronze | 25 | 50 | ..... | ..... | ..... | ..... | ..... | 25 | |
| Nickeloy | 1.41 | 4.15 | ..... | ..... | ..... | 93 8 | ..... | ..... | Cast gives 20,000 lbs./sq.in. tensile strength, 4.5% elongation. |
| Nickel manganese bronze | 2 5 | 53.4 | ..... | 39 | 1.7 | 0 2 | 0 3 | 2 6 | |
| Nickel-tungsten | 25–50 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | W 50–75. Alloy for mixing. |
| Nickel-zirconium | 86.4 | ..... | ..... | ..... | ..... | 6 | ..... | ..... | Si 6, Zr 1.5, C 0.1. High speed cutting tools |
| Plastic bronze | 1 | 64 | ..... | ..... | ..... | ..... | 30 | 5 | |
| Platinite | 46 | ..... | 54 | ..... | ..... | ..... | ..... | ..... | 46% nickel. |
| Platinum substitute | 72 | ..... | ..... | ..... | ..... | 23 6 | ..... | ..... | Bi 3.7, Ar 0.7. |
| Platnam | 58 8 | 32 55 | 0 48 | ..... | ..... | 0 32 | 12 72 | ..... | Used for valve seating. |
| Roscin | 40 | ..... | ..... | ..... | ..... | 30 | ..... | 20 | Ag 10. Used for jewellers' work. |
| Sea water bronze | 32 5 | 45 | ..... | 5 5 | ..... | ..... | ..... | 16 | Bi 1. Resistant to sea water. |
| Sheathing bronze | 32 5 | 45 | ..... | 5 5 | ..... | ..... | ..... | 16 | Bi 1.5. |
| Sidiraphite | 23 | 5 | 65 | ..... | ..... | ..... | ..... | ..... | W 4, Sb 3. |
| Speculum | 4 | 64 | ..... | ..... | ..... | ..... | ..... | 32 | For telescope mirrors. Does not always contain nickel. |
| Stanniol | 0 3 | 1 | 0 1 | ..... | ..... | ..... | 2 4 | 96 2 | |
| Stellite | 1 | ..... | 2 | ..... | ..... | ..... | ..... | ..... | Co 75, Cr 16.5, Si 3-4, C 2. Pocket and table knives, surgical instruments, machine tools. |
| Stuffing box alloy | 15 5 | 61 5 | ..... | 11 | ..... | ..... | 10 | 2 | For turbines. |
| Toncas metal | 28 6 | 35 | 7 | 7 | ..... | ..... | 7 | 7 | Sb 7. Ornamental work. |
| Trabuk | 5 5 | ..... | ..... | ..... | ..... | ..... | ..... | 87 5 | Sb 5, Bi 2. Substitute for nickel silver; resistant to vegetable acids. |
| Tungsten brass | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | See wolfram brass. |
| Turbadium bronze | 2 | 48 | ..... | 46 | ..... | ..... | ..... | ..... | |
| Turbiston bronze | 2 | 55 | 0 84 | 41 | 0 16 | 1 | ..... | ..... | Resistant to salt water. |
| Typewriter metal | 20 | 57 | ..... | 20 | ..... | 3 | ..... | ..... | Used for typewriter parts. |
| Unmagnetizable watch wheels | 18 | 18 | ..... | ..... | ..... | ..... | ..... | ..... | Pt 62.75, Cd 1.25. Used for watch wheels. |
| Warnes metal | 26 | ..... | ..... | ..... | ..... | ..... | ..... | 37 | Bi 26, Co 11. |
| White gold | 59 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Au 41. Substitute for platinum. |
| White gold | 15 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Au 80. Substitute for platinum. |
| White solder | 10 | 45 | ..... | 45 | ..... | ..... | ..... | ..... | Soldering. |
| Wolfram brass | 14 | 60 | ..... | 22 | ..... | ..... | ..... | ..... | W 4. |
| Zamium | 60 | bal. Cr, Mn, W. | | ..... | ..... | ..... | ..... | ..... | A nickel-chromium alloy, resistant to corrosion. |

cent manganese for sparkplug terminals has been mentioned. The characteristic which renders this group of nickel alloys of value for these purposes is their resistance to oxidation and alteration at the higher temperatures (up to 2,000 deg. F.) at which they are used, in conjunction with their high electrical resistivity, low temperature coefficient of electrical resistivity and either high or low thermal electromotive force against iron or copper.

The principal base metal thermocouples are copper against constantan, iron against constantan (Leeds and Northrup, Bristol, Brown pyrometers) and Chromel against alumel (the Hoskins thermocouple). The temperature-electromotive force relations of these three elements are given in Table VI, quoted from Foote, Harrison and Fairchild,[12] the values being average or standard ones. Adams[12] has shown how to apply deviation curves based on one temperature-electromotive force measurement to lots of such wire having slightly different relations.

The alloys used for electrical heating and for the construction of rheostats or electrical resistances may be divided into several groups: (1) The nickel:chromium alloys having a high electrical resistivity, low temperature coefficient together with maximum resistance to oxidation and alteration at higher temperatures; (2) the ferronickel alloys with lower resistivity and resistance to oxidation but considerably cheaper; (3) copper:nickel alloys having lower resistivity and inferior heat-resisting properties than the first class, but with practically negligible temperature coefficient of resistivity at ordinary temperatures, a very necessary property in the construction of precise electrical resistances for measuring instruments, and (4) the alloys similar to nickel silver, which are the oldest alloys used for electrical purposes and are being displaced by the others.

The compositions of alloys manufactured commercially today are listed in Table VII, together with approximate compositions and physical properties, principally as described by the manufacturers owning the patents. Most of these alloys are furnished in wire and in ribbon form and are manufactured by melting either in crucibles or electric furnace, pouring into small ingots which are first hot-rolled, annealed, and then cold-drawn with annealing into the finished form.

[12]Bulletin 153, Am. Inst. Mining Eng.

The alloy constantan, or copper:nickel, which also is sold under a number of trade names, is chiefly used for pyrometer and electrical resistance wire. It may be rolled at the temperatures (1,175 to 1,200 deg. C.) used for Monel metal and annealed at a slightly lower temperature—i.e., 850 deg. C. The tensile properties of copper:nickel alloys containing approximately 45 per cent of nickel will average as follows:

| | ¼-in. Hot-Rolled Wire Rod | Annealed Wire | Hard-Drawn Wire |
|---|---|---|---|
| Tensile strength, lb. per sq.in. | 65-85,000 | 60,000 to 65,000 | 110,000 to 140,000 |
| Elongation in 2 in., per cent | 25-40 | ..... | ..... |

The general subject of electrical resistance has received much attention by Hunter and Sebast,[13] and Sebast and Gray.[14] An alloy of very high resistivity (113 michrom-cm.) and of negligible temperature coefficient (0.000078 per deg. C.) was found containing 17 per cent chromium, 71 per cent nickel and 12 per cent copper which would appear to have commercial possibilities; it resists oxidation at higher temperatures to a remarkable degree and is easily manipulated in drawing. An alloy was found containing 48 per cent copper, 39 per cent nickel and 10 per cent manganese which has a resistivity of 70 microhm-cm. and zero temperature coefficient at 20 deg. C.; this is superior to manganin in its higher resistivity. The highest values of the resistivity were found in the binary nickel:manganese and nickel:chromium and in the ternary ferronickel:manganese, ferronickel: chromium and copper: nickel: chromium alloys. The ternary alloys have a higher value of the resistivity than the binary alloys. Alloys of low temperature coefficient were found chiefly among the copper: nickel: manganese alloys.

An interesting corollary of the development of electrical resistance alloys for rheostats and heaters has been that of heat-resisting alloys, and many compositions used at first because of their electrical- and heat- or high temperature-resisting properties are now used because of the latter alone. Nickel: chromium alloys in the form of castings are now much used for furnace muffles, carbonizing and annealing boxes and pyrometer protection tubes. These alloys (see Table VII) withstand very well the action of gas and oil flames as well as that of molten lead, cyanide or of carbonizing mixtures at temperatures up to 2,000 deg. F. (1,100 deg. C.).

### Miscellaneous Alloys

Besides its use as a principal alloying element in the well-known alloys just considered, nickel enters into the composition of a great variety of other commercial and experimental alloys, in which it acts perhaps principally to increase the hardness without an appreciable loss of ductility. However, it is also considered to exercise other functions. In Table VIII are assembled data on the chemical composition and use of a number of miscellaneous alloys in commercial use or mentioned in the literature which contain nickel; this table does not include alloys which have been listed in former tables covering nickel:silver alloys and those for electrical purposes.

Nickel is a powerful decolorizing agent for metals such as copper and gold. Several jewelers' white alloys are produced today as substitutes for platinum under the name of white gold; they contain from 20 to 50 per cent of nickel, with the remainder gold.

[13] *J. Am. Inst. Metals*, vol. 11, p. 115 (1917).
[14] *Trans.*, Am. Electrochem. Soc., vol. 29, p. 569 (1916).

An alloy of 90 per cent nickel and 10 per cent tin is used to some extent for valve seats and rings.

Nickel in small amounts has been found to exert a beneficial effect on copper: lead-bearing bronzes in preventing the segregation of the lead. Thus, a much-used railway bearing bronze for heavy bearings contains:

| | Per Cent | | Per Cent |
|---|---|---|---|
| Copper | 64 | Lead | 30 |
| Tin | 5 | Nickel | 1 |

An alloy of nickel and zirconium called Cooperite (see Table VIII) after its discoverer has been patented for machine tools and appears to have shown some very interesting test results in comparison with ordinary high-speed steel.

# Legal Notes

By Wellington Gustin

## General Rules of Water Purification Board of Rhode Island Do Not Aggrieve Corporations or Persons

Appeals of the Standard Oil Co. of New York and the Mexican Petroleum Corporation from orders of the Board of Purification of Waters of the State of Rhode Island have been dismissed in the Rhode Island Supreme Court.

The board was established under an act to prohibit and regulate the pollution of waters of the state and thereafter made an order establishing certain rules and regulations to prevent the discharge or escape of any petroleum, gasoline, kerosene, tar, oil or any product or mixture thereof into the public waters, as it was empowered to do under section 8 of the act. The corporations claimed that they were aggrieved by this order and were entitled to appeal from such order to the Supreme Court. They set up about twenty grounds upon which they contended that the order was unlawful and unreasonable.

To illustrate these rules the second regulation is here stated: "(2) No person shall discharge, or cause, suffer or procure to be discharged, or cause or suffer to escape into any of the public waters of the state any petroleum, gasoline, kerosene, tar, oil, or any product or mixture thereof."

It was charged that such rule and regulation is unlawful because the escape of such products is prohibited irrespective of whether or not such escape causes pollution of the waters; that on the same ground it is unreasonable; and that it is unlawful and unreasonable on the further ground that the escape of the above-mentioned products is prohibited irrespective of the circumstances, reason or cause for the same.

### Property Rights Determine Right to Appeal

However, the court said the right to appeal from such order is given only to those who are aggrieved by the finding of an inferior tribunal, and the party is "aggrieved" where the judgment or decree operates on his rights of property or bears directly on his interest. Neither of the corporations had been made the subject of proceedings under the act, but they feared some act or omission in the future might be complained of under some provision of chapter 1,914, and that such provision as applied to the circumstances of a case which might arise would be unlawful or unreasonable.

However, the court pointed out that the law requires the board, after it finds any person polluting the water, to order such person to prevent such pollution, and section 7 of the act prohibits prosecution without an order finding a violation, and section 10 prohibits conviction except for violation of the order of the board. It said the adoption of rules of the board under the authority of section 8 does not affect any person's property, but such rules are admonitory in character, and therefore do not "aggrieve" any person so as to authorize an appeal therefrom.

There was a strong dissenting opinion filed.

## Rule Laid Down Where Defendant May Examine Plaintiff Before Trial

In the case of R. M. Jones against the Union Guano Co., Jones appealed to the Supreme Court of North Carolina from an order of the Superior Court of Rockingham County permitting the company to proceed with an examination of plaintiff before trial.

This case is one of nineteen actions in the Rockingham Supreme Court by nineteen farmers against the Union Guano Co. for damages for alleged breach of warranty in certain fertilizers causing them losses in their crops. After the complaint in this case was filed, the defendant filed a petition to examine the plaintiffs to obtain information on which to file its answer. The plaintiffs were directed to appear for examination on April 19, 1920, on which date they filed an answer to the petition and order, and asked that the order be set aside. The trial judge directed that the defendant should proceed with the examination of the plaintiffs and Jones appealed, the eighteen cases to await and abide the decision in this case.

This proceeding for the examination of the opposite party before trial may be permitted to the plaintiffs to procure information to frame the complaint (116 N. C., 480). Or after answer is filed the plaintiff may cause the defendant to be examined to procure evidence (18 Am. State Rep., 893). And likewise the rule extends to the defendant so to examine the plaintiff. But the Supreme Court said this right does not lie where, as in this case, the grounds of action are fully set out in the complaint, and the defendant can deny the same, or if so disposed it may answer on information or belief.

### Cannot Spread Dragnet for Adversary

As to both parties to a suit the court said in the case of Bailey vs. Matthews (156 N. C., 78): "The law will not permit a party to spread a dragnet for his adversary in the suit, in order to gather facts upon which he may be sued; nor will he countenance any attempt, under the guise of a fair examination, to harass or to oppress his opponent. It is a very rare case that requires the exercise of this function of the court, and the order should not be made without careful consideration and scrutiny."

The complaint filed by Jones and his eighteen associates, the court said, was a clear, specific statement as to the purpose for which the fertilizer was bought and the constituent elements which it was represented to contain by the Guano company, and allegations of the falsity of such representations and of the damage. It was said that the defendant did not need any examination of the plaintiff to enable it to answer these allegations.

It was laid down as the rule that an application for an order for an examination be under oath, stating facts showing the nature of the action, is such that the testimony desired is relevant and that the examination is material and necessary and the information desired is not already accessible and that the application is made honestly and in good faith, and not maliciously. These requirements had not been met, the court said.

## Guarantee of Product by Another Is a Direct Obligation and Need Not Be in Writing

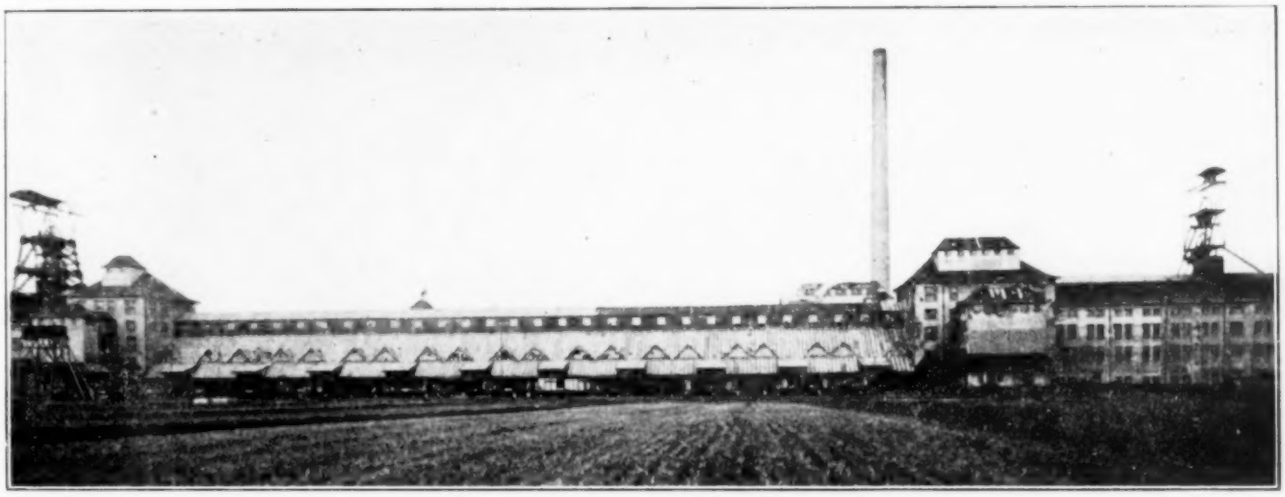
In a recent case the proposition of guaranty was considered by the Supreme Court of California. It appears that the Simons Brick Co. employed the Interstate Vaccine Co. to vaccinate hogs with anti-cholera serum on the personal warranty or guarantee of one Wiglesworth that such vaccination would render the hogs immune from cholera, and that he would pay for any hog vaccinated which subsequently died. Afterward the Simons Brick Co. brought action against Wiglesworth and recovered judgment for $5,637.20. Two questions were presented on appeal from this judgment. The first was as to whether there was a contract, and the second was as to whether such contract, if it did exist, was one which had to be in writing under the statute of frauds.

In passing on the question the court said that defendant's statement, that if the Brick company would employ a particular company and its product he would personally warrant or guarantee the results, was a proposal which had to be accepted within such time as the parties contemplated it would remain open, and, in the absence of express understanding, within such time as they reasonably had in mind under the circumstances. The facts showed that the offer of warranty was to remain open and that the employment of the company some months afterward was on an understanding of which the guaranty was a part.

### Not Every Guarantee Must Be in Writing

As to the point made that the promise of guarantee was not in writing, the court said not every promise which may be aptly termed a "guarantee" is required to be in writing. It is only where the guarantee is a promise to answer for the debt, default or miscarriage of another that it must be in writing under the universal statute of frauds.

The question presented is: Was the promise of defendant one to answer for the obligation of another? The only other for which it could be considered that he intended to assume responsibility was the serum manufacturer. But it was not shown that any obligation of guaranty existed on the part of the manufacturer. There being no contract of warranty between the plaintiff and the manufacturer, the law implies a warranty or agreement that reasonable skill and care will be exercised in the selection and application of the vaccine, but that is all, nor were there any facts in the case from which an express warranty could be inferred between them. Since no warranty as sued upon existed between plaintiff and the manufacturer of the product, the agreement of defendant to pay for any hogs vaccinated which subsequently died was not a contract to answer for the debt or default of another—all of such contracts being required to be in writing under the statute of frauds. Such a guarantee of a product is a direct and separate contract, obligating the guarantor alone, and is enforceable, although not in writing.



GENERAL VIEW OF REICHSLAND PLANT

# The Alsatian Potash Industry

**Location and Extent of Alsatian Sylvinite Deposits—Physical Characteristics—Mining Methods—Surface Treatment: Crushing and Refining—Status of the Mines Before and After the War—Improved Operating Methods—Distribution of Products**

BY HENRI VIGNERON
Consulting Engineer, Société Commerciale des Potasses d'Alsace.

AS FAR back as 1869 borings were made in the vicinity of Mulhouse in search of petroleum and oil. Only the presence of common salt was discovered. More recently, in 1904, other searches were made; the first borings, near Wittelsheim, showed common salt at a depth of 1,100 ft. At a depth of 1,900 ft. the first layer of potash was found, and a second layer at a depth of 1,950 ft. It is interesting to note that the presence of potash would probably not have been discovered had it not been for the curiosity of Joseph Vogt, Sr., an Alsatian, who, noticing the red color of the salts, had them analyzed.

## EXTENT OF THE DEPOSITS

Encouraged by the results, a company was formed to determine the limits of the basin. One hundred and sixty-five borings were made, varying from 750 to 3,000 ft. in depth. These proved the existence of a very large deposit of potash salts (sylvinite) over an area of about 68 square miles. It was also shown that there were two layers, or strata, of potash; the top layer containing a high percentage salt, 20 to 25 per cent $K_2O$, the lower layer containing potash salts varying from 15 to 18 per cent $K_2O$. The limits of the basin and the upper and lower deposits are shown on the map, Fig. 1.

During the war the battle front was very near the mines. L'Hartmannswillerkopf, or "Old Armand," that mountain of the Vosges where the "Blue Devils" (Alpins Chasseurs) resisted the attacks of the German army for three years, is only two miles from the shafts of the mine Marie-Louise.

The French did not destroy the mines, as they believed they would be restored to France some day; therefore the Germans continued to operate them within range of the French guns. Unfortunately, when the French took possession of Alsace they found that the enemy, in retreating, had left the mines in a deplorable condition. All the shafts in process of construction were flooded. Those mines that were in active exploitation were left in such a state that it took many

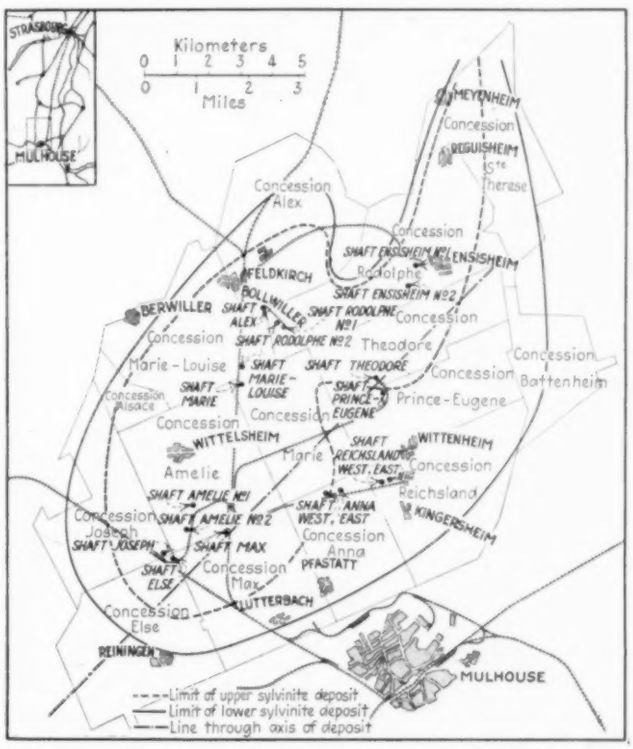



FIG. 1. LOCATION OF ALSATIAN POTASH DEPOSITS

months and great expense to put them in working order. In spite of the difficulties, notwithstanding labor troubles and depression among workmen due to undernutrition, in spite of the absence of a technical personnel, the reconstruction of the mines was immediately commenced. Since that time, thanks to the unceasing work of the French engineers, the Alsatian mines have

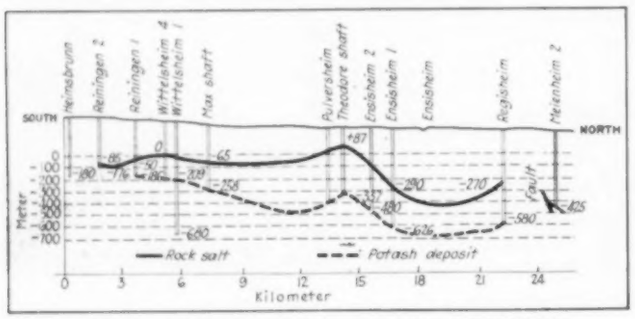



FIG. 2. SECTION ALONG AXIS OF DEPOSITS

reached a production power which the reader will be able to appreciate from the following discussion.

It has already been stated that the deposit consists of two layers. These differ in grade and are about 60 ft. apart. The upper layer, 3.8 ft. in thickness, contains from 35 to 40 per cent of potassium chloride, or 22 to 25 per cent $K_2O$. This layer is found at a depth of 1,500 ft. at Amelie, 1,650 ft. at Theodore, 1,900 ft. at Alex, 2,500 ft. at Ensisheim. The lower layer is 7.5 ft. in thickness at Reichsland; 13.5 ft. at the mines Marie and Marie-Louise, and 16 ft. at the mine Amelie. Its nature varies from 23.5 to 32 per cent KCl, or 15 to 20 per cent $K_2O$.

The borings, which were made at various points, prove that the basin assumes the form of an ellipse, the axis of which passes through Ensisheim, running northeast to southwest. The northern end of this ellipse is prolonged by an additional strip which extends as far as Oberentzen. The western boundaries are formed by the Vosges and Harz Mountains, where the strata become thinner.

A cross-section (Fig. 2) following the axis of the ellipse as indicated by the dot-and-dash line in Fig. 1, shows that the deposit of potash salts, at a depth of 550 ft. at Reinigen, sinks to approximately 1,900 ft. at Ensisheim, only to rise again later.

The average analysis of Alsatian potash salts is as follows:

| | Crushed Raw Salts | | Refined Salts | |
|---|---|---|---|---|
| | Sylvinite, 14 to 16 per Cent | Rich Sylvinite, 20 to 22 per Cent | KCl, 50 to 60 per Cent | KCl, 60 to 62 per Cent |
| $K_2O$ | 14-16 | 20-22 | 50-60 | 60-62 |
| KCl | 21-25 | 32-35 | 79-95 | 95-98 |
| NaCl | 55-67 | 50-55 | 4-5 | 4-0.7 |
| $MgCl_2$ | 0.1-0.7 | 0.1-0.5 | 0.1-0.5 | 0.05-0.1 |
| $MgSO_4$ | none | none | none | none |
| $CaSO_4$ | 2-5 | 2-4 | 0.3-0.4 | 0.1-0.3 |
| $H_2O$ | 0.7-1.2 | 0.5-1.2 | 0.3-1.5 | 0.1-0.3 |
| Insoluble: Clay, $Fe_2O_3$ | 10-14 | 9-12 | 0.5-5 | trace |

Fig. 3 shows the cross-section of the shaft Theodore, which is situated in the center of the basin at Wittenheim.

The shafts are from 15 to 18 ft. in diameter. At the opening, the casing, which continues to a depth of about 300 ft., is of cast iron and from this level to the bottom the shaft is lined with a casing of concrete from 1 to 1½ ft. in thickness.

The following table gives the composition of the successive layers encountered in sinking the shafts:

| Strata | Depth m. | Thickness m. | Depth ft. | Thickness ft. |
|---|---|---|---|---|
| Soil | 0 | 0.3 | 0 | 1 |
| Sand and gravel | 0.30 | 21.95 | 1 | 72 |
| Fossiliferous blue clay | 22.25 | 58.57 | 73 | 193 |
| Gray, brown and blue clay | 81 | 60.5 | 266 | 198 |
| Rock salt with alternate clay strata | 141.5 | 404.3 | 464 | 1327 |
| Upper sylvinite deposit | 545.8 | 1.25 | 1791 | 4 |
| Slate, etc. | 547.05 | 18.0 | 1795 | 59 |
| Lower sylvinite deposit | 565.05 | 4.10 | 1854 | 13 |
| Rock salt | 569.15 | 6.85 | 1867 | 23 |
| Slate | 576 | 4 | 1890 | .... |

## Physical Characteristics of the Potash Beds

In the descent into one of the potash mines nothing can be seen of the deposits passed in the shaft, because they are covered by the concrete lining of the shaft, or, near the top, by a metal collar. The first sight of any of the underground deposits is obtained as one steps from the mine cage into the mine workings. Here broad entries, well lighted by electricity, have been excavated in the thicker of the two potash beds. The galleries branch in various directions and are closed here and there by doors (brattices), which are needed to direct the circulation of the air that is forced through the mine for ventilation. Figs. 4 to 7 are typical views of the mine workings.

The sight of the potash salts in place is striking. High walls of sparkling crystalline salts are banded in approximately horizontal stripes of red and white, more or less wavy, giving the impression of a portion of an immense flag. (See Fig. 7.) On clean mine faces the colors are beautifully clear. Some of the bands are a deep, rusty red or brick red. Other portions are delicately pink, and there is much white and gray granular crystalline material. The belief that the red and some of the pink salts are directly associated with the richer potash portions of the bed is so generally expressed throughout the field that it must have some foundation in fact, although perfectly white or transparent crystals of almost pure potassium chloride have been found. Examination in detail shows that the coarse crystals, both red and white, are much intermixed, and it is not usually possible to trace a distinct boundary

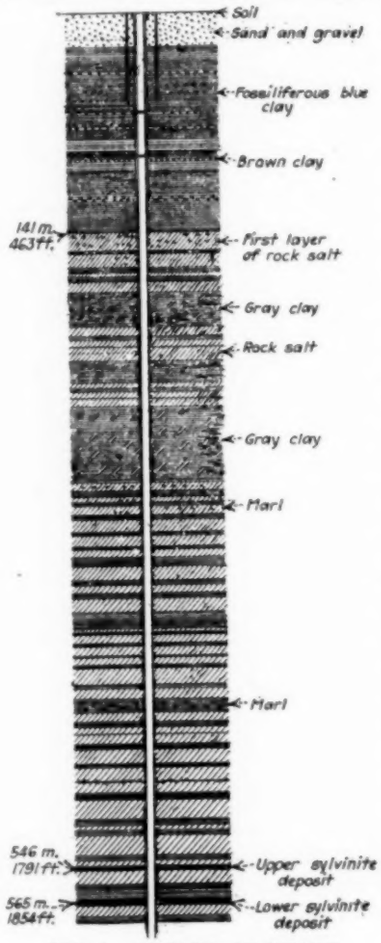
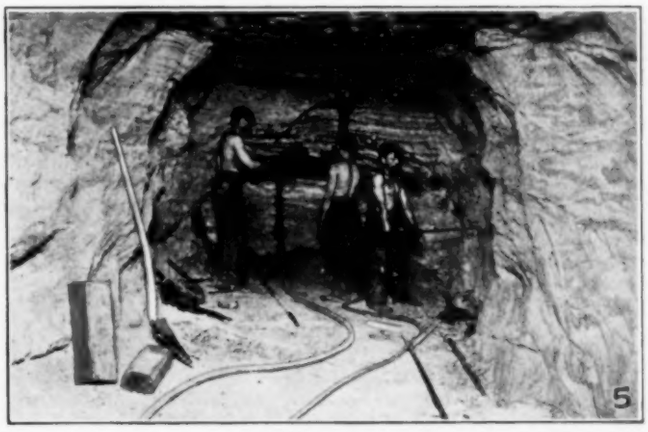
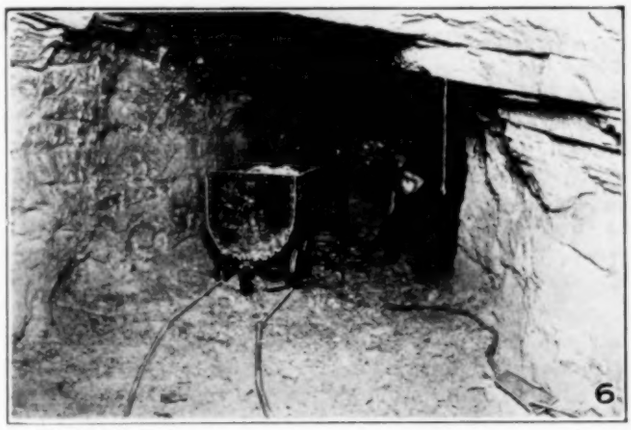
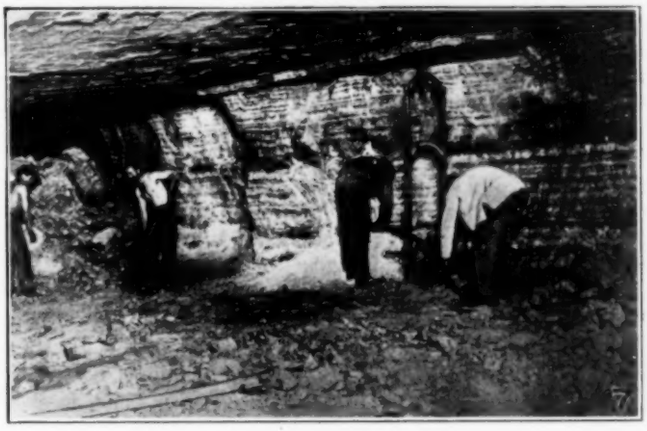



FIG. 3. STRATA AT SHAFT THEODORE




TYPICAL VIEWS OF THE MINE WORKINGS

Fig. 4. One of the main galleries.
Fig. 5. Drilling at the end of a gallery.
Fig. 6. Loading cars at the end of a gallery.
Fig. 7. Present method of mining.

between them, but in general aspect the banding is very distinct.

The top and bottom of the potash beds, where the salts rest against adjacent clay or shale seams, are very clearly defined. The shale leaves a very clean surface in the roof of the mine, marked by some irregular pits or patches, but usually breaking clean from the salts. This is also true of the clearly defined shale seams that occur within the potash bed.

The two beds preserve their individual characteristics, including general thickness and relation to each other, as well as details of the shale partings and chemical character of the constituent members, with remarkable constancy throughout the field. The upper bed, containing a richer grade than the lower bed, is the thinner.

## Mining Methods

The room-and-pillar method of mining was employed by the Germans. Long parallel evacuation galleries from 475 to 650 ft. in length and from 140 to 200 ft. in width were used to remove salt from the minor galleries. The large wall separating these parallel galleries was removed during the process of mining. Inasmuch as no shoring or timbering was used, pillars or columns 6 ft. square and 12 ft. apart were left as supports. A map or plan of the galleries gives one the impression of a large checkerboard. These pillars were too weak to support the great weight of the roof and very often would break under the enormous overhead pressure. The Germans tried to reinforce them, filling in spaces with hollow wooden columns, the centers of which were filled with common salt (the waste byproduct obtained in the manufacture of muriate). This method gave no security either against cave-ins, which frequently occurred without warning, or against firedamp, caused by the bituminous slate forming the roof of the strata.

Electric and compressed air drills are used, and from 500 to 600 g. of explosive materials are required for each ton of crude salt extracted. The temperature in the galleries is about 95 deg. F., but the ventilation system employed reduces this to a temperature of about 80 deg. in the working galleries.

## Surface Treatment

Some idea of the extent and arrangement of the crushing and refining plants can be gained from Figs. 8 to 10. The salts are brought to the surface by electric or steam hoists (Fig. 11). Rotary dumps (Fig. 12) discharge the contents of the cars into storage bins. From these the salts pass to a jaw crusher, where the coarser lumps are broken to about the size of a man's fist, and the material is then spread on a revolving table, where it is sorted hurriedly by one or several workers, who remove the larger lumps of waste that happen to come to the surface with the rest. From this table it is fed to a lower level into grinding mills, which are of several types. From these the material either passes into storage for shipment as crude salts or goes into the refinery. The arrangement of the crushing machinery is shown in Fig. 13.

If the material is to be refined, it is elevated and passed through a screen. The fines, relatively cleaner and purer, go directly to boiling vats, and the coarse material, which includes more shale, is returned to the

mills for regrinding. It is then transferred, usually by belt, into hoppers, from which at intervals it is fed into boiling vats fitted with agitators.

### Refining

The refining is based on the difference in solubility of the mixture of chloride of potassium and chloride of sodium in hot or in cold water. As shown by the solubility curves, Fig. 14, one hundred c.c. of water can dissolve:

| | KCl | NaCl |
|---|---|---|
| | g. | g. |
| at 100 deg. C..... | 35.9 | 25.7 |
| at 10 deg. C..... | 12.5 | 29 |

A warm saturated solution of potassium chloride and of sodium chloride deposits 23.4 g. of potassium chloride on cooling, but as the solution is not saturated in sodium chloride this latter does not precipitate. Actually, due to loss by evaporation, a little of the sodium chloride is also precipitated.

The raw salts are heated with mother liquor derived from previous crystallizations, at about 225 deg. F. The liquors and salts from these solution vats are discharged periodically, and the residue is drawn into draining vats which have perforated bottoms and revolving rakes, the latter assisting the draining of the residue while it is still hot (at about 195 deg. F.). When the free liquor is practically all run off, the residue is thrown out at the edge by means of the revolving rakes and goes to waste, usually being returned to the mine to fill old workings. The moist residue still contains several per cent of potash.

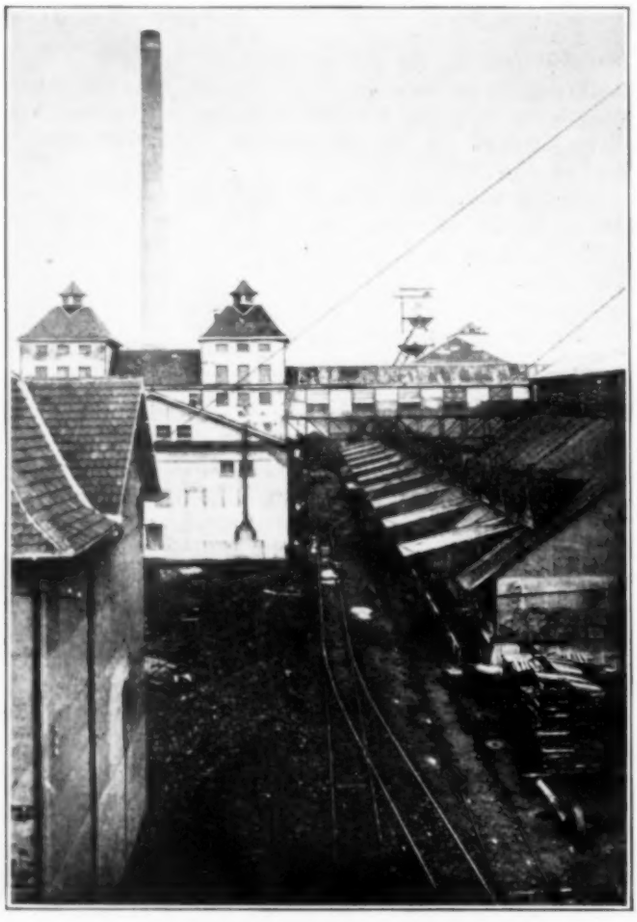


FIG. 8. GENERAL VIEW OF AMELIE MINE

FIG. 9. ANOTHER VIEW OF AMELIE MINE

The liquor then goes to settling vats, where it stays about fifteen minutes, beginning to crystallize on the surface almost at once. A long glass tube thrust into the solution, then closed at the top and withdrawn, shows the progress of settlement of the muddy slime, and a hinged drainage pipe is let down into the vat, so that its outlet end follows the rather distinct limit of the clear liquid. The mud and salt left in the bottom of the tank are again washed with hot mother liquor.

The liquor, which is still distinctly muddy and with a temperature of about 195 deg. F., is drawn from the settling tanks through troughs to a battery of iron crystallizing vats of the ordinary type (Fig. 15), where as it cools it deposits the crop of muriate (potassium chloride) of varying degrees of purity, the quantity and quality of the product obtained depending somewhat on the care with which the various steps of the process are conducted, the length of time allowed for crystallizing and the amount of chilling. After the mother liquor has stood for several days it is withdrawn and returned to the process. The crust that forms with each cooling is from 2 to 5 in. thick on the sides of the tanks and somewhat thicker at the bottom. The salt is dug out of the crystallizers by hand and loaded over the sides into tramcars, whence it is taken to a rotary drier, where any surplus moisture is removed before bagging.

The coal consumption is about 600 lb. for 1 ton of muriate of potash, and 3 tons of crude salts are used to produce 1 ton of muriate.

### Status of the Mines During and After the War

The following table gives the quantities of crude salts extracted from various mines during the war:

| | 1913 Tons | 1914 Tons | 1915 Tons | 1916 Tons | 1917 Tons | 1918 Tons |
|---|---|---|---|---|---|---|
| Reichsland ..... | 15,103 | 38,847 | 41,364 | 50,335 | 81,787 | 79,674 |
| Amelie I ..... | 137,876 | 53,335 | 14,434 | ..... | ..... | 3,290 |
| Amelie II..... | ..... | 30,550 | ..... | ..... | ..... | ..... |
| Max ..... | 35,656 | 23,048 | 2,250 | 37,086 | 43,378 | 34,818 |
| Joseph ..... | 21,875 | 23,197 | ..... | ..... | ..... | ..... |
| Else ..... | 23,665 | 23,826 | ..... | ..... | ..... | ..... |
| Theodore ..... | 47,608 | 39,244 | 22,698 | 90,623 | 159,044 | 173,706 |
| Prince Eugene .. | 47,608 | 39,243 | 22,698 | | | |
| Marie ..... | 9,634 | 15,143 | 5,457 | 12,910 | 4,344 | 27,151 |
| Marie-Louise ... | 7,080 | 15,143 | 5,457 | 13,220 | 27,701 | |
| Alex ..... | 1,600 | 24,310 | ..... | 300 | 3,877 | 14,860 |
| Rudolph ..... | 2,636 | | | | | |
| Total ..... | 355,341 | 325,886 | 114,358 | 204,474 | 320,131 | 333,499 |

From this is noted the very large quantity extracted from the mines Theodore, Prince Eugene and Reichsland during the year 1917-1918. This intensive extraction left the galleries in such a deplorable condition

that it took many months' labor and much expense to get them in working order. The elevator of the Alex mine, which was undermined by water when the shaft was flooded, was repaired during the war by the German management, but it is only since the French regained possession of the mines that pumping out and reparation has been undertaken in the other flooded shafts. The shafts Marie and Else have been repaired. The shaft Rudolph has been pumped out, but about 600 ft. of masonry must be repaired and a new elevator installed. The shaft Ensisheim I has been pumped dry and entirely repaired. Sinking, which must go down to approximately 2,600 ft., has been continued. The shaft Ensisheim II is in a similar state. As soon as the shaft has been pumped dry, it is necessary to repair at once the concrete lining in order to prevent further seepage of water. Seepage commences in most of the mines, especially in Anna I, at about 600 ft. below the surface.

When one takes into consideration the wasteful methods employed by the Germans and the deplorable con-

FIG. 10. HEADFRAME AT AMELIE SHAFT

dition in which they left the mines, some conception can be obtained of the enormous difficulties encountered and successfully overcome by the French engineers.

It has been stated above that the Alsatian potash deposit consists of two layers: One from 9 to 12 ft. in thickness; the other from 3 to 4½ ft. in thickness, the latter lying only 60 ft. above the former. The Germans, with their usual lack of foresight and wasteful methods, commenced operations on the lower layer first, and inasmuch as no supports or timbering were

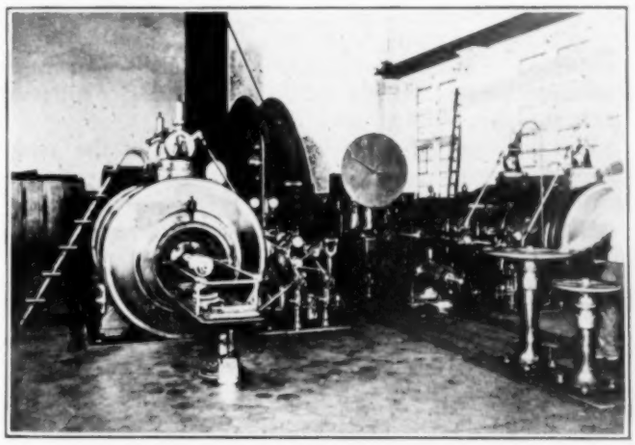


FIG. 11. STEAM HOISTING-ENGINE

used, this rendered exploitation of the upper layer very difficult, if not dangerous. In some parts this upper layer, which contains the richest salt, may be considered as lost.

In order to protect the shafts, the working galleries are begun only beyond a circle whose radius depends on the depth of the shaft, leaving shaft pillars which prevent the weakening of the strata surrounding the pits. Otherwise the concrete lining of the shafts would crack and break, rendering them unfit for future use. The Germans started their working galleries within a radius of 150 ft. Had this method been continued, cave-ins would have been inevitable and in a short time the mines would have been completely ruined. This practice has been stopped and measures have been taken to insure both the safety of the shafts and the machinery. Therefore the shaft pillars have been extended from 150 ft. to 600 ft. by French engineers.

### Precautions Against Firedamp

The Germans were fully aware of the presence of firedamp, yet they did nothing to guard against this enemy of the miner. Firedamp in the potash mines comes from the slate beds located either in the roof or walls in the vicinity of the layer. It exudes from the slate beds only when the latter are reached by drilling or are dislocated by sinkings. Otherwise, the slate beds contain a very small amount of firedamp, since notwithstanding the experiments made with air currents in the old unembanked work, where the roof sinks by degrees, its presence is not revealed. Firedamp in the Alsatian mines is dangerous only when

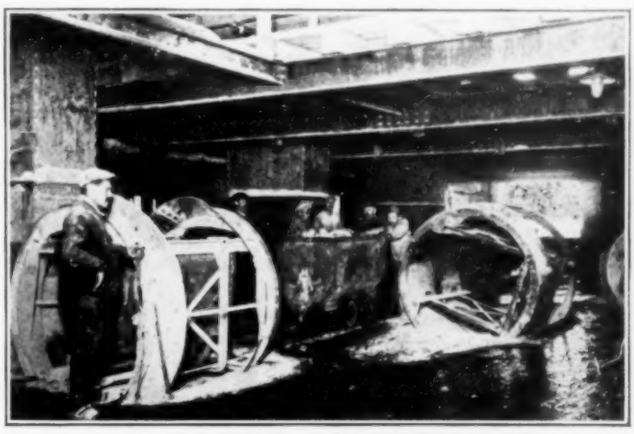


FIG. 12. ROTARY DUMPS

sudden landslides occur in the parts worked by the room-and-pillar method. In this event the small amount contained in the slate is quickly freed and produces a sufficient amount of gas to form a flammable mixture with the surrounding air.

The principal precautions to be taken in the avoidance of accidents due to firedamp are known, and are as follows: The use of safety lamps; good ventilation; the suppression of instantaneous liberations of firedamp by use of modern mining methods.

None of these precautions was taken by the German exploiters. The lamps used were ordinary acetylene or flame lamps. The ventilation was the natural one created between the connecting shafts of each working. There were ventilators in some of the mines, but none were in working order. No preventive measures were taken against instantaneous emissions of firedamp. At the shafts Theodore and Marie-Louise the work was done by the room-and-pillar method, which left square pillars 12 to 15 ft. with unshored spaces.

At the shaft Amelie long chambers 15 to 19 ft. wide were worked, leaving 15 ft. of salt between the chambers. This pillar-and-chamber method was somewhat better than the one employed at the shafts Theodore and Marie-Louise, in the sense that the long walls are more resistant to cave-ins than the pillars, in that they allow only a slow sinking of the roof and a slow influx of firedamp. However, this method is no guarantee against sudden possible sinkings. In addition, 25 per cent of the salts at Theodore and Marie-Louise was lost by the use of this method, and 40 to 45 per cent at Amelie.

Various precautions have been adopted in order to lessen this danger of coal gas. Flame lamps have been

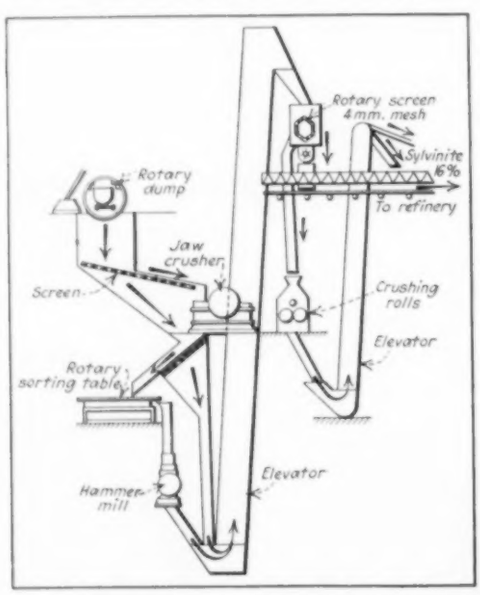



FIG. 13. CRUSHING AND GRINDING MACHINERY

replaced by safety lamps. The new directors, who were formerly directors of coal mines, use natural ventilation, which, by a system of deflectors or doors, forces the air through all the working galleries. These are used wherever they were formerly installed. The possibility of the formation of firedamp has been lessened by abandoning the room-and-pillar method of mining and by using instead the pillar-and-chamber method in those parts where bracing is still impossible.

Another method of mining is being tried at the present time to prevent all sudden cave-ins and thus reduce to a minimum the dangers of firedamp. This will have, among other advantages, that of allowing the removal of all the salt, whereas by the German method, 25 to 50 per cent was lost. Thanks to the new arrangements of the galleries and improved ventilation, the work has been facilitated. In this manner, cave-ins of the roof of the galleries will be prevented. Nevertheless, the danger from firedamp is extremely small. There is no continuous emission of gas, as it is never detected in the air coming from the mine.

### Storing Explosives in the Mines

The removal of the salt is done by the use of explosives, generally compressed black powder. Since the

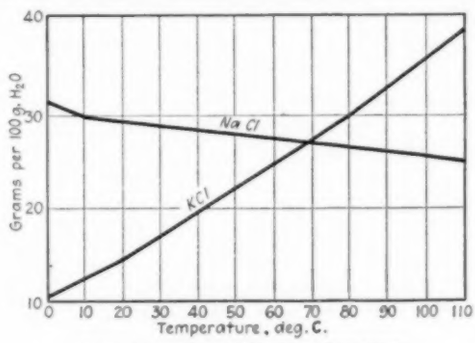



FIG. 14. SOLUBILITY CURVES

consumption for each ton of crude salt is a little over a pound, the total consumption for a shaft which has a daily output of 500 tons will be from 550 to 600 lb. Thus it is necessary to have a large quantity of explosives in the mine proper. Fulminate of mercury detonators are used, and these are very sensitive to shock.

The Germans, regardless of the danger to life as well as to the safety of the mines, stored large quantities of explosives and detonators together. The correct procedure is to distribute the explosives to the miners in separate rooms far from the main storerooms, so that if an explosion occurs during the handling of the cartridges, it will not be communicated to the whole supply. At present, detonators are in separate rooms and the distribution rooms are at some distance from the supply rooms.

### Weighing Apparatus

It is absolutely necessary that in a plant which sells only a fraction of its product in the crude state and

FIG. 15. CRYSTALLIZING TANKS

the remainder as refined, there should be weighing apparatus in order to know exactly the quantity delivered to the plant, and therefore to know exactly the yield. The Germans had no scales and there were weighing machines for the cars only, and no attempt was made to increase production.

### Difficulties Overcome by New Management

Other instances of the peculiarities in the German methods of working the mines are: The exaggerated length of the research galleries, which run in directions without any rhyme or reason; the floor level of the main galleries is irregular; in the mine Amelie, for example, the width of the tracks is not the same for the two communicating parts of the mine, so that the cars of one part cannot go to the other shaft.

All these numerous errors committed by the Germans imperiled not only the future of the mines but also constituted a permanent danger to the safety of the miners. In all cases the less important mistakes only occasioned heavy operating expenses and prevented the mines from reaching their highest state of development. These errors are so numerous that one is led to believe that they were made intentionally to hinder the future development of the basin.

It is not only these obstacles that the French have overcome but it is also necessary to repair and install new machinery, mobilize an entirely new and efficient executive staff, capable of meeting all conditions and of rendering, by modern methods, a highly developed organization, capable of supplying the potash needs of the entire world.

### Facilities for Distribution of Products

Alsace-Lorraine has ample transportation facilities to insure quick delivery to all parts of the work, either by water or by rail. When the Rhine is navigable, the potash is shipped by rail to Strasbourg, where it is loaded on barges which proceed directly to Antwerp, at which point it is loaded on steamers. When the Rhine is too low to permit navigation, the potash is shipped directly from the Alsatian mines to Dunkirk or Antwerp, and from there by steamer to the various markets of the world.

In order to facilitate the sale and distribution of Alsatian potash salts, the Société Commerciale des Potasses d'Alsace was formed with one end in view—i.e., giving service and satisfaction to its buyers in order to come into more direct touch and intimate relations with the largest market of the world, namely, the American. As an indication of ability to supply the American market, the following tonnages are announced as available for export to the United States between May 1, 1921, and March 31, 1922:

| | Tons | $K_2O$ Tons |
|---|---|---|
| Kainite (sylvinite), 14 per cent | 420,000 | 60,000 |
| Manure salts (rich sylvinite), 20 per cent | 500,000 | 100,000 |
| Muriate of potash, 50 per cent | 100,000 | 50,000 |
| High grade muriate of potash, 60 per cent | 12,000 | 6,000 |
| | 1,032,000 | 216,000 |

For sales purposes, the lower grades are referred to as kainite and manure salts because these terms have become firmly established in the trade.

The Société has recently opened its United States bureau in New York at 25 West 43rd St. The object of this bureau is to come into direct touch with the American fertilizer manufacturer and to increase the good feeling which has always existed in the past between the American consumer and the Alsatian potash industry.

# Some Synthetic Resins From Furfural

By Gerald H. Mains and Max Phillips

A PRACTICAL method for the cheap production of furfural, 2-furfuraldehyde, $C_4H_3O.CHO$, has recently been devoleped in the Bureau of Chemistry,[1] and furfural promises to become one of the cheap organic chemicals. Relatively few commercial uses have as yet been developed for this product, and the bureau is now carrying on an investigation for the development and extension of this field. The present paper is a preliminary report on one phase of the work.

### Results Reported in the Literature

That furfural reacts with various compounds, especially phenols and amines, to form products of a tarry or resinous character more or less indefinite in composition has long been recognized in the literature.[2] The scarcity and very high cost of furfural made these reactions, however, of very little importance. During the past four or five years furfural has been produced on a small scale in France from wood and kapok waste. The recent work of Roger Adams at the University of Illinois,[3] and of LaForge,[4] Monroe[5] and the authors at this bureau has further demonstrated the practicability of securing in this country furfural in large quantities and at a reasonable cost from corncobs. Thus the possibility of producing synthetic resins from furfural is brought within the realm of economic importance.

A good foundation has been laid for the study of the formation of the hard or infusible type of resin by the condensation of furfural with phenols in the rather extensive investigation of Beckmann and Dehn.[6] Meunier[7] has made some resins of the soft, fusible and soluble type by the action of furfural with sodium hydroxide, ammonia, acetone and aniline. The present paper will be limited to a consideration of this latter type, which is suitable as a varnish resin. We have made a more extended study of the conditions under which the resins described by Meunier are formed, and have studied the formation of soluble resins by the condensation of furfural with a number of other compounds.

### Experimental

The method of attack was to determine first the optimum concentrations of amine (or other compound under test) and furfural for the formation of a resin at room temperature, approximately 25 deg. C. Five-gram portions of furfural were used and from one-fifth to three times that weight of the other compound. Where no resins at all were obtainable at room temperature the optimum concentrations were determined at 100 deg. C. Using the concentrations which gave the best results in the previous experiments, resins were made at certain readily obtainable laboratory temperatures: room temperature, 25 deg. C.; the temperature of boiling water, 100 deg. C., and that of a paraffine

[1] The work on the production of furfural was suggested by Dr. F. B. La Forge of this bureau, and is an outgrowth of the general corncob utilization project which he is developing. *Cf. J. Ind. Eng. Chem.*, vol. 10, p. 925 (1918), *Chem. Age*, vol. 28, p. 332 (1920).

[2] *Cf.* J. Persoz, *Wagner's Jahres-Bericht der Chem. Technologie* (1860), p. 487; J. Stenhouse, *Proc. Roy. Soc.*, vol. 18, p. 537 (1870).

[3] Roger Adams, O. Kamm and C. S. Marvel, Univ. Ill. Bull. 16, No. 43, p. 5 (1919).

[4] *Loc. cit.*

[5] K. P. Monroe: U. S. Pat. 1,357,467; *J. Ind. Eng. Chem.*, vol. 13, p. 133 (1921).

[6] E. Beckmann and E. Dehn, *Sitzb. kgl. preuss. Akad.* (1918), p. 1,201; *Chem. Abs.*, vol. 14, p. 642 (1920).

[7] George Meunier, *Mat. Grasses*, vol. 9, p. 4,516 (1916).

bath, 150 to 200 deg. C. Having determined the optimum temperature, the length of time necessary under the given conditions to form the most satisfactory resin was similarly investigated.

It might appear that the temperature could have been more finely adjusted than in our experiments, but in view of the fact that the resins are not pure compounds, but products of an indefinite and varying composition, and that the same consistency of resin can be produced over a rather broad range of temperature by varying the length of heating period, it was felt that in this work we should hold to certain readily obtainable temperatures and let the time be the variant. Our criterion of the quality of the resin was simply that it should be hard and fairly brittle when cooled to room temperature and yet not noticeably carbonized.

In some cases no resins were formed without the addition of a catalyst. Beckmann and Dehn[5] used hydrochloric acid as a catalyst in their work on making infusible resins by condensation of furfural with phenols. We have found that hydrochloric acid is an exceedingly effective catalyst in producing resins from furfural. It not only effectively catalyzes the formation of both fusible and infusible types of resins from furfural and other compounds, but added to furfural alone causes the formation of an infusible resin. Its salts are also catalysts, but not quite as effective.

The results obtained with each compound follow, the reactions being carried on in an open flask unless otherwise stated, and all proportions being given by weight.

### Condensation With Amines

*Aniline.* Equal parts of furfural and aniline heated for one hour at 200 deg. C. in an open flask or for three hours at 170 deg. C. in a flask attached to a reflex condenser give a black resin, hard and brittle at 25 deg. C.

*Aniline Hydrochloride.* Equal parts of furfural and aniline hydrochloride heated at 100 deg. C. for one hour produce a black resin, hard and brittle at 25 deg. C.

*Aniline plus Hydrochloric Acid.* Five parts each of furfural and aniline and one part of concentrated hydrochloric acid, sp.gr. 1.19, give a resin similar in characteristics to the above in ten minutes at 90 deg. C.

*m-Nitraniline.* By heating one part of furfural and two parts of *m*-nitraniline at 150 deg. C. for one hour and fifteen minutes a black resin becoming hard and brittle at 25 deg. C. may be obtained. If the temperature exceeds 175 deg. C. a violent reaction occurs giving off voluminous clouds of dense brown smoke.

*Cymidine plus Hydrochloric Acid.* Five parts of furfural, five parts of cymidine (1-$CH_3$.2-$NH_2$.4-isopropyl benzene) and one part of hydrochloric acid (sp.gr. 1.19) heated at 150 deg. C. for ten minutes give a dark reddish brown resin very hard and brittle at 25 deg. C. Without the presence of hydrochloric acid no resin is formed even after heating for three hours at 200 deg. C.

α-*Naphthylamine.* When heated for three hours at 200 deg. C. one part furfural and two parts α-naphthylamine condense to form a black resin, hard and brittle at 25 deg. C.

β-*Naphthylamine.* One part of furfural and two parts of β-naphthylamine mixed at room temperature, 25 deg. C., give the immediate formation of a reddish-brown hard, brittle resin.

*o-Toluidine plus Hydrochloric Acid.* By heating five parts of furfural, ten parts of *o*-toluidine and one part of hydrochloric acid (sp.gr. 1.19), for one hour at 150 deg. C., a black resin is produced which is very hard and brittle at 25 deg. C. Without the addition of the hydrochloric acid no appreciable thickening of the liquid is found even after heating for three hours at 200 deg. C.

*p-Toluidine.* One part of furfural and two parts of *p*-toluidine heated for two and one-half hours at 150 deg. C. produce a black resin becoming hard and brittle when cooled at 25 deg. C.

*m-Toluylenediamine.* Equal parts of furfural and *m*-toluylenediamine, upon standing over night at room temperature, 25 deg. C., give a dark brown, hard, brittle resin.

*Xylidine plus Hydrochloric Acid.* By heating five parts of furfural, five parts of xylidine (crude mixed) and one part of hydrochloric acid (sp.gr. 1.19) together for fifteen minutes at 150 deg. C., a very thick, dark red, almost black, resin is formed, very hard and brittle at 25 deg. C.

*Other Amines.* No resins were formed by the action of furfural on amylamine, dimethylaniline, diphenylamine and *m*-phenylenediamine even after heating at 200 deg. C. for three hours. Furfural condensed with the following at room temperature to form crystalline compounds: *p*-nitraniline, benzidine and toluidine.

### Condensation With Ketones

*Acetone plus Sodium Hydroxide.* One part of furfural, one part of acetone and two parts of 50 per cent sodium hydroxide solution when heated in flask attached to a reflux condenser for thirty minutes at 100 deg. C. condense to give a dark brown solid mass. By washing out the excess alkali with dilute acid, drying at 100 deg. C. and cooling to room temperature a hard, brittle, brown resin is formed.

*Methyl Ethyl Ketone plus Sodium Hydroxide.* Five parts of furfural, two parts of methyl ethyl ketone and five parts of 50 per cent sodium hydroxide solution give almost immediately at room temperature, 25 deg. C., a dark brown gum. By washing out the excess alkali with dilute acid, drying at 100 deg. C. and cooling to room temperature, a hard brown resin is obtained.

### Miscellaneous Condensation Reagents

*Ammonium Hydroxide (Furfuramide Resin).* To an aqueous solution of furfural an excess of ammonium hydroxide is added. The furfuramide formed, partially dried and heated for one hour at 100 deg. C., gives a reddish brown resin hard at room temperature.

*Sodium Hydroxide followed by Hydrochloric Acid.* One part of furfural and seven parts by weight of a 25 per cent sodium hydroxide solution are heated together for one hour in a flask attached to a reflux condenser. Concentrated hydrochloric acid (sp.gr. 1.19) is then added in excess and a black resin is formed, the excess of acid is washed out and a medium hard tar is formed which gradually becomes brittle upon standing.[6]

### General Properties of Resins Produced

The resins do not have sharp fusion points, softening gradually till fluid. The softening temperature of the resins made as described lie between 25 and 100

[5] *Loc. cit.*

[6] The conditions for forming this resin are satisfactory only within a narrow range. If more dilute acid than the above is used a poor resin or none at all is formed. If the excess hydrochloric acid is not thoroughly removed the resin will change to the insoluble and infusible type.

deg. C., but have not been carefully determined, since the softening point can be raised to almost any reasonable temperature desired by simply heating the resins at higher temperatures or for a longer period of time.

All of the above resins are practically insoluble in water. They are somewhat soluble in turpentine, quite soluble in benzene, acetone and alcohol, and very soluble in furfural. The acetone, benzene and furfural solutions of these resins form varnish stains which when applied to wood give shades ranging from golden brown to black, depending upon the resin, the concentration of the solution and the number of coats applied. The surfaces thus coated have a glossy appearance.

### Applications

Of the furfural resins described those which are produced from cheap enough materials to be of possible practical importance at the present time are: furfur-aniline, furfur-α-naphthylamine, furfur-*o*-toluidine, furfur-xylidine, furfur-acetone, furfur-methyl ethyl ketone, furfur-amide, and furfur-sodium hydroxide resins.

The appearance of the varnish stains on white oak when the resins are applied in a single coat from the saturated benzene and furfural solutions is given in Table I.

TABLE I. APPEARANCE OF FURFURAL VARNISH STAINS ON WHITE OAK

| Resin | Shades Given by One Coat of Resin — Applied in Saturated Benzene Solution | Shades Given by One Coat of Resin — Applied in Saturated Furfural Solution |
|---|---|---|
| Furfur-aniline | Light brown | Dark brown |
| Furfur-α-naphthylamine | Dark brown | Nearly black |
| Furfur--toluidine | Medium brown | Dark brown |
| Furfur-xylidine | Dark reddish brown | Dark reddish brown |
| Furfur-acetone | Golden brown | Dark brown |
| Furfur-methyl ethyl ketone | Golden brown | Golden brown |
| Furfur-amide | Reddish brown | Reddish brown |
| Furfur-sodium hydroxide | Medium brown | Dark brown |

By allowing the furfural solutions to evaporate somewhat and applying several coats, furfur-aniline, furfur-α-naphthylamine, furfur-*o*-toluidine and furfur-xylidine resins give beautiful black enamels. The furfur-sodium hydroxide resin also gives a black enamel, not quite as good as the others.

The resins are all derived from furfural, and furfural is an excellent solvent for them. The source of furfural, corncobs, is practically unlimited, and with a large demand the price will be very low.[10]

### Conclusions

With the improvement by the Bureau of Chemistry of the processes for the production of furfural cheaply and on a large scale, resins made from it become of economic importance. The optimum conditions for the production of fusible resins suitable for use in varnishes by the condensation of furfural with amines, ketones and other compounds are given. It is shown that eight of these resins—namely, furfur-aniline, furfur-α-naphthylamine, furfur-*o*-toluidine, furfur-xylidine, furfur-acetone, furfur-methyl ethyl ketone, furfur-amide and furfur-sodium hydroxide resins—can be produced from cheap enough materials to be of practical importance under present conditions. The varnish stains given by these resins in benzene and furfural solutions and their appearance when applied to oak are described.

Color Laboratory,
U. S. Bureau of Chemistry,
Washington, D. C.

[10] Furfural was quoted in this country at $65 per lb. in 1917, $30 in July, 1920, $20 in December, 1920, and $10 in January, 1921, is being produced in this laboratory (even with a very small apparatus) at a cost of less than $3 per lb., and we estimate can, on a large scale, be produced for less than 10c. per lb.

# Synopsis of Recent Chemical & Metallurgical Literature

**Growing Uses of Magnesium.**—The late war has contributed to a better appreciation of the important properties of magnesium metal, and its industry is now growing steadily. Its most useful properties are the low specific gravity (1.75), the great affinity for oxygen, and the very high heat of combustion. These last two properties make it one of the best reducing agents in metallurgy. As a deoxidizing agent it is utilized for the purification of aluminum, copper, nickel, brasses, bronzes and alloys of copper and nickel. When introduced in a galvanized material it gives a thinner and more brilliant coating. It is to be expected that it will be used as a deoxidizer in the steel industry as soon as means are found to slow down the intensity of its oxidizing action.

The alloys of magnesium, especially the magnesium:aluminum alloys, are bound to be used more extensively, due to their being very light. During the war the Germans made extensive use of a 90Mg:10Al alloy known under the name of elektron. Alloys known as magnalium, with 30 per cent Mg, have their resistance greatly improved by mechanical work such as forging, hammering and drawing. Other important magnesium alloys are known under the names of zimalium and duralumin. The demand for light and at the same time resistant alloys in the aëronautics industry especially is growing fast.

The electric and thermic properties of magnesium are also very important. Its electric conductivity is about 30 per cent of that of copper and, taking its thermic conductivity as 100, that of aluminum and of iron would be respectively 86.5 and 9.8.

The Société d'Electrochimie et d'Electrométallurgie of Clavaux (Isère) is now working extensively on the development of the magnesium industry.—*J. du Four Electrique*, March 1, 1921, p. 23.

**Dissolved Gases in Glass.**—All varieties of glass, even at ordinary temperatures, are in the liquid state of aggregation. They are liquids which have been cooled through their normal crystallization interval so rapidly that there has not been time for crystallization ("devitrification") to occur. In principle any liquid can by supercooling be brought into the condition of a glass, but since it still remains a liquid, it should possess the characteristic properties of liquids, including the power to hold gases in a state of solution.

During the process of manufacturing glass, large quantities of gas, mainly carbon dioxide, oxygen and nitrogen, are evolved from the batch owing to reactions such as:

$$Na_2CO_3 + SiO_2 = Na_2SiO_3 + CO_2$$
$$4KNO_3 + 2SiO_2 = 2K_2SiO_3 + 2N_2 + 5O_2$$
$$2PbO_2 + 2SiO_2 = 2PbSiO_3 + O_2$$

On cooling the glass these gases should remain in solution and glass in the finished state may therefore be expected to contain appreciable quantities of these dissolved gases. Since no data concerning the nature or amounts of such dissolved gases were available, experiments were undertaken by E. W. Washburn, F. F. Footitt and E. N. Bunting. The preliminary results have been published in Bulletin 118 of the Engineering Experiment Station, University of Illinois.

The existence of dissolved gases was demonstrated by melting a piece of perfectly clean homogeneous glass under atmospheric pressure in a vacuum furnace connected through a valve to a large evacuated tank. When the temperature reached about 1,200 deg. C. the valve was opened quickly, thus causing a sudden drop of pressure within the furnace. On opening the furnace (after cooling) most of the glass was found outside the pot, standing above it in the form of a large white mass of foam about six times the size of the original piece.

By the use of specially designed apparatus, analyses were made of the gas content of three types of commercial glass:

A barium flint optical glass; a light flint bulb glass; a borosilicate laboratory glass. Carbon dioxide, oxygen and nitrogen were found in varying amounts, the total volume (measured under standard conditions) being from 0.2 to 2 times that of the glass itself.

Evolution of dissolved gas tends to occur in the form of bubbles or "seed" whenever the pressure on glass, while in the fluid state, is decreased. Such a condition is met with in cases where the glass is "gathered" by suction, as in the case of the Owens machine. If the glass when it reaches the gathering machine is supersaturated with dissolved gases, the operation of gathering will evidently result in the formation of seed, some of which will not disappear again when the suction is released.

Results thus far attained indicate that a vacuum furnace process for the manufacture of certain types of glass is entirely feasible on an industrial scale, and that it offers a number of pronounced advantages over current methods. It eliminates entirely the fining operation as ordinarily understood, materially reduces the high finishing temperatures required with some glasses, produces in all cases a product absolutely free from even the smallest seeds, and these results suggest the possibility of considerably increasing the yield of perfect glass. Its main field of usefulness will probably be in the manufacture of certain types of optical glasses and in the manufacture of glass for high-vacuum apparatus.

# Recent Chemical & Metallurgical Patents

## American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

**Ammonium Sulphate.**—Ammoniacal gas from coke ovens is led through coolers to a gas exhauster followed by a tar extractor. From the tar extractor the gas, moist and cooled, passes into the cracker pipes of the first two of three saturator compartments, which are separated by partitions but provided with connecting ducts for the overflow and interchange of portions of the saturation bath. The moist gas gives up its ammonia with relatively limited formation of ammonium sulphate and without appreciable incrustation within the saturator or salting up of the cracker pipes through which the gas enters. The ammonia-freed gas is passed through an acid separator and a heater and is then returned to the third compartment of the saturator, where it supplies the heat required for evaporation and consequent deposition of ammonium sulphate from the saturation bath. By means of an elaborate system of pipes, valves and bypasses, the order of the three saturator compartments may be changed at will. Separation of tar and ammonia liquor and recovery of the latter by distillation are accomplished in the usual manner. (1,366,111; JOSEPH BECKER, of Pittsburgh, Pa., assignor to the Koppers Co.; Jan. 18, 1921.)

**Diaphragm for Electrolytic White Lead Cell.**—In carrying out the Harrington process for the electrolytic manufacture of white lead considerable difficulty was experienced in obtaining diaphragms possessing the necessary mechanical strength, durability and the proper degree of porosity. It was practically impossible to maintain a cell in uninterrupted operation for more than a few days. An improved diaphragm has been designed by ELMER A. SPERRY, of New York, which permits of continuous operation for many weeks. One method of making such a diaphragm is as follows: A piece of duck canvas of suitable size and preferably of comparatively fine weave is first freed of grease by treating it with a caustic solution. The fabric is then subjected to a strong sulphuric acid bath (1.750 sp.gr.) for a length of time depending on the osmotic and impervious qualities desired, say 30 to 45 min. Excess acid is washed off and finally neutralized in a bath containing about 5 per cent of sodium or ammonium hydroxide. Such diaphragms swell when moist and tend to crack and tear when allowed to dry on frames. It is necessary therefore, that they be kept moist before and after they are mounted on the frames. The chief difficulty in accomplishing this is to prevent the drying of that portion of the diaphragm which is unsubmerged in the electrolyte. This area is best covered by strips of treated cloth large enough to dip in the electrolyte and sufficiently absorbent to draw up electrolyte by capillary action and thus keep the diaphragm moist. (1,368,227, assigned to Anaconda Lead Products Co.; Feb. 8, 1921.)

**Ammonium Perchlorate Blasting Powder.**—Ammonium perchlorate explosives of relatively low strength are desirable for use in many operations but, as ordinarily made, they cannot be used in wet work; they harden and set during storage, and they are relatively insensitive. ARTHUR LANGMEIER of Dover, N. J., has found that a coating of trinitrotoluene on the particles of ammonium perchlorate and sodium nitrate used in this class of explosives not only renders the powder waterproof but facilitates storage and makes it possible to explode the charge with a No. 6 standard detonator. It is essential that the trinitrotoluene should form a protective film and not be present simply as an ingredient of a mixture. The ammonium perchlorate and sodium nitrate are placed in a steam-jacketed crystallizing and agitating kettle maintained at a temperature above the melting point of trinitrotoluene. After adding the trinitrotoluene the mixture is cooled with constant agitation. A preferred composition is as follows: 20 per cent ammonium perchlorate coated with TNT; 49 per cent sodium nitrate coated with TNT; 20 per cent trinitrotoluene; 10 per cent sulphur; 1 per cent wood pulp. (1,367,608; assigned to Hercules Powder Co.; Feb. 8, 1921.)

**Fused Silica.**—Fused silica articles may be made by reducing silica to plasticity in an electric resistance furnace and then blowing the plastic mass into molds. However, at the temperature required for this purpose gas is given off from the carbon or graphite core. This gas diffuses through the plastic mass and the finished article is therefore not homogeneous. By surrounding the resistance core with a thin graphite tube somewhat larger than the core, a space is formed through which the gases may escape. The space between this thin tube and a larger two-part graphite jacket is filled with the silica to be fused. After current has been passed through the core for a sufficient time, a plastic cylinder of fused silica is formed. This is then removed from the furnace and placed in a mold. A graphite nozzle is inserted in the hole through the center of the mass and superheated steam admitted under pressure so as to cause the mass to take the shape of the molds. (1,368,990; JOHN SCHARL, of New York, assignor to General Ceramics Co.; Feb. 15, 1921.)

**Coke-Oven Construction.**—A more uniform coke is obtained in an oven constructed so that the distillate can be drawn off in the usual way until the peak temperature is reached and can then be drawn off in the opposite direction. Steam is also admitted during the latter phase of the operation and the upper parts of the coking chambers are interconnected. The vapors and gases in passing downwardly through the charge have a cooling effect on the hotter portions of the charge and a local circulation is induced which causes heat to pass from the hotter portions to the relatively cooler portions of the charge, thereby preventing over-coking in the hotter zones but accelerating the coking of the under-done portions of the charge in the cooler zones. In addition, the steam acts according to the water gas reaction (which is endothermic), thereby absorbing much heat which would otherwise effect over-coking. In order to insure an efficient reversal of flow a channel-forming rod is forced into the bottom of the chamber by the pusher and left there until the charge has hardened enough to permit of its withdrawal without disturbing the channel. (1,369,673; HEINRICH KOPPERS, of Essen-Ruhr, Germany, assignor to Koppers Development Corp.; Feb. 22, 1921.)

# Current Events
## in the Chemical and Metallurgical Industries

### Chemical Warfare Service Dinner

What is expected to be a highly representative gathering of those interested in chemical warfare will take place in Washington April 16 at the annual dinner of the Chemical Warfare Service. At this dinner it is expected that a chemical warfare association will be launched.

The program has been arranged so that the chemical, as well as the military, side of the service will be brought out. Brigadier-General William Mitchell, of the air service of the Army, will discuss plans and possibilities of aërial offenses against battleships, which involve the use of smoke screens and gases. Brigadier-General Amos A. Fries will present some of the problems with which the Chemical Warfare Service now is wrestling and will outline the present character of the work being done under his direction.

General Pershing and Admiral Sims have been invited to attend and to reply to toasts.

More than 1,000 invitations have been sent out. Every effort has been made to reach all former Chemical Warfare Service officers and all reserve officers attached to that service. Arrangements are in charge of Major F. R. Maddux, of General Fries' staff. The dinner is a subscription affair and will be held at the Army and Navy Club.

### Federated American Engineering Societies Activities

Permanent headquarters of the Federated American Engineering Societies have been established in Washington. A desirable location has been secured on the third floor of 719 Fifteenth St., N. W. (National Savings and Trust Building). Sufficient space has been obtained to accommodate the staff of the F.A.E.S. and at the same time provide a large lounging room or conference room for those who may desire to use the headquarters as a meeting place. It will be the purpose of the headquarters at all times to render as much personal service as possible to engineers who visit Washington. A special plan will be developed to the end that engineers visiting Washington may be able to transact business with the minimum amount of effort on their part. Engineers, therefore, are asked to notify it of an intended visit to Washington so that arrangements may be made to care for them. The executive secretary, L. W. Wallace, will be permanently located in Washington in the near future.

There is great activity in a number of states regarding the licensing of engineers. The F.A.E.S. has in every instance taken a part in such legislation. It has made an effort to have a representative at every meeting. It is not the desire of the F.A.E.S. to initiate such legislation nor to urge its passage, but it does take the position that it desires to be instrumental so far as possible toward securing the passage of a bill that will not be detrimental to public interests and to the engineering profession.

A very careful study is being made by the Employment Service conducted under the auspices of the F.A.E.S. This study purposes determining what policies should be adopted that will enhance the value and usefulness of the service to the individual members of the member-societies. This report will be submitted to the executive board at its meeting on April 16.

#### Work of Committee on Elimination of Waste in Industry Progressing Favorably

The work of the Committee on Elimination of Waste in Industry is progressing according to schedule. It is now assured that all the field work will be completed on or before April 15. The publication of the final report of the committee will be undertaken immediately upon the completion of the field work. A definite program has been evolved for this phase of the work. Since the field investigation is going according to schedule, it is expected that the final report will also do so. The report will be published some time in June. The findings of the committee thus far are very significant and it has every reason to believe that the publication of this report will create a great deal of interest. The finest of co-operation has been obtained from all agencies approached. This has greatly aided the committee in its work.

There is a large interest on the part of engineering societies that have not yet become affiliated with the F.A.E.S. In recent weeks two have joined—namely, the Boston Society of Civil Engineers and the Engineering Society of Milwaukee. There are a number of other societies that are either voting upon it at the present time or have it under consideration by the executive board. It is reasonably sure that a number of other societies will become affiliated with the F.A.E.S. before July 1, at which time the opportunity of coming in as a charter member will expire.

The next meeting of the executive board is to be held in Philadelphia on April 16. The executive board will be the guests of the Philadelphia Engineering Club and the sessions will be held at the Engineers Club. The club is making preparations to have a large and interesting attendance. There is to be a dinner at the Bellevue-Stratford on the evening of April 16 which is to addressed by the president, Mr. Hoover. A very large attendance of engineers is being arranged for. It is expected that this will be one of the most important meetings that the board has ever held.

### American Engineering Standards

About a year ago the American Engineering Standards Committee was organized, and much of the time and effort of the committee has since been spent in laying a basis for an extended program. Considerable progress has already been made in the unification of the more important standards and in overcoming the confusion that was being produced by the numerous organizations (more than 100) that hitherto published engineering standards without systematic co-operation among themselves.

The committee itself is composed of forty-seven members representing seventeen bodies or groups of bodies, including six national engineering societies, five governmental departments and thirteen national industrial associations. Its function is merely to see that each body or group concerned in a standard shall have opportunity to participate in its formulation, which is in the hands of a working committee, technically called a "sectional committee." Each sectional committee is organized by and under the leadership of one or more of the principal bodies interested, such bodies being known as "sponsors." Sponsorships have been arranged for thirty-eight projects which were under way by the beginning of 1921.

An important part of the committee's work relates to safety codes. On Dec. 8, 1920, at a conference at which more than 100 organizations were represented it was unanimously voted that a comprehensive program of safety codes should be undertaken, to be carried out under the auspices of the American Engineering Standards Committee, to insure proper co-ordination and elimination of overlap, etc. Active work is now in progress on twenty-four such codes including "Foundries," "Gases," "Paper and Pulp Mills," "Refrigeration," "Presses," with hearty co-operation among the state commissions, associations of insurance companies, national engineering societies, manufacturers' and industrial associations, labor and civic organizations and technical bureaus of the Federal Government.

## Organization of Petroleum Section, A.C.S.

The organization of a Petroleum Section has been authorized by the officers of the American Chemical Society, and it is proposed to hold the initial meeting of this section at the general meeting of the Society at Rochester, April 26 to 29.

For the Rochester meeting Dr. Thomas G. Dolbridge, Atlantic Refining Co., Philadelphia, has been appointed chairman and Dr. W. A. Gruse, Mellon Institute, Pittsburgh, secretary.

The purposes which this organization is expected to fulfill may be expressed as follows:

(1) To enable chemists and technologists engaged in the petroleum, shale-oil and natural gas industries to meet and to correspond, and to accumulate trustworthy information regarding the geochemistry of petroleum, oil-shale and natural gas, the conversion of the raw materials into manufactured products, and the characteristics and usages of these products, together with their transport and storage.

(2) To promote the better education of persons desirous of becoming petroleum engineers, refinery engineers or hydrocarbon chemists, and to elevate the professional status of those employed in the industries mentioned by establishing a high standard of scientific and practical proficiency.

(3) To encourage hydrocarbon chemistry.

(4) To co-operate with the American Petroleum Institute and with the National Research Council, and to collaborate with the American Society for Testing Materials in its work on the standardization of bituminous and petroleum products.

Fifty chemists and chemical engineers actively engaged in the petroleum industry have pledged their support and co-operation, and fifteen papers on the chemistry of petroleum have been promised for the first meeting. At this meeting it is desired also to take up such questions as that of the degree and scope of the activities of the section, the form of co-operation with other technical and scientific societies, the exact name of the section, and other interesting points. If time permits, it is planned to hold an informal symposium on the problems of the petroleum and allied industries.

All persons who desire to become members of the section are requested to send their names to the secretary. A full attendance at this organization meeting is urged and the submission of papers is solicited.

The secretary will be glad to have any suggestions which this announcement may call forth.

## Chemical Problems in Cottonseed Oil and Jelly Manufacture

Monday evening, April 4, before the Rochester Section of the American Chemical Society and guests, Donald Howe, chief chemist of the Beechnut Packing Co., gave a talk on cottonseed oil and its products.

The byproducts of the vast cotton industry enter into the manufacture of many and various materials and articles of common use, such as lacquers, soap, salad oil, celluloid, etc. As in most other industries, the last few years have seen attention turned to use of heretofore waste products. It has been largely through the work of the chemist that these waste products have been converted into useful and marketable materials, and very often, as in the case of the cotton industry, the byproducts have a money value nearly equal to the main product.

For many years salad oil meant only olive oil. With the increasing cost of this oil a search was made for a desirable substitute. At first there was a good deal of popular opposition to the use of anything but olive oil for salads. The nutritive value of both peanut and cottonseed oil is practically the same as for the more expensive olive oil, and as for the taste, as Mr. Howe said, you really cannot tell the difference.

Cotton is raised in the Southern States, where the climate is semi-tropical. After picking, the cotton is taken to the gin and the seeds are removed. The seeds are graded according to moisture and quality, the latter depending on the amount of decay, size and other points. The moisture should be lower than 10 per cent, otherwise the seeds may ferment and spoil.

The seeds are cleaned and the hulls cracked just enough to break the hulls but not to crush the seed. They are then screened to remove the hulls. The meats are then taken to the presses, where the oil is removed from the seed. The material left after removing the oil is called oil cake, which is a desirable cattle feed, having a high protein and fat content. When oil cake was first tried as a cattle feed the thinnest, poorest looking cattle were fattened, meanwhile being periodically weighed, the occasion being marked by a parade to the village scales. This practical method was one of the most effective pieces of advertising.

The oil as it is pressed from the seed is neutralized and refined. It contains some stearine, a fat having a high melting point. This is easily removed by simply cooling the oil, and as stearine solidifies it can be filtered off. The oil is bleached by fuller's earth.

With the increasing cost of lard the industrial food chemists made every effort to find a less expensive desirable substitute. They turned to cottonseed oil, but to get the oil to a solid at ordinary temperature was the problem. This was finally accomplished by the use of nascent hydrogen, which will convert the oleic acid of the oil into stearic acid of the fat having a higher melting point and being a solid at ordinary temperatures. Nickel is used as a catalyst in the hydrogenation which solidifies the oil.

This lard substitute, coming under various trade names, is a desirable and satisfactory shortening agent for all kinds of cooking. It is also well to note that its food value is about the same as lard.

### Manufacture of Jelly

Mr. Howe told something about commercial jelly making and its corresponding laboratory problems. It is only within a few years that jellies have been made on a commercial scale. The old family cook book gives directions to the effect that not more than six glasses should be made at one time to be certain of the best results. But the making of jelly has been commercialized, even as most other household duties have. Jelly is made from the juice of fruits boiled down with sugar. The ability of the fruit juice to "jell" is determined by the proper combination of pectin, acid in the fruit, and sugar. Pectin is a complex carbohydrate present in certain fruits, such as apples, currants, oranges and lemons, and when boiled is converted into pectic acid, which forms calcium pectate with the calcium salts always found in the fruit.

Pectic acid and calcium pectate set to a jelly when certain fruits are boiled with water and the juice allowed to cool. When certain fruits, such as strawberries, which contain very little pectin, are desired for jelly pectin must be added. So much water should not be added to fruits that it will be necessary to boil the juice for a long time, because the acid present will so change the pectin that it will lose its ability to "jell."

At the close of his talk Mr. Howe treated the Section to Beechnut molasses popcorn bars, salad dressing and jelly.

Harry A. Carpenter, chairman of the registration committee for the National Convention, received the registration fees of those present and announced that the badges would be given out at the next meeting.

Prof. Ernest J. Woodland, president of the Section, announced that the speaker for the next regular meeting, April 18, would be Dr. Alsberg, chief chemist of the United States Bureau of Chemistry.

## Civil Service Examinations

Vacancies in the Chemical Warfare Service, Edgewood Arsenal, Edgewood, Md., will be filled from the following open competitive examinations announced recently by the Civil Service Commission:

Chemist, $3,000 to $5,000 a year. Apply on Form 2118.

Associate chemist, $2,000 to $3,000 a year. Apply on Form 2118.

Junior chemist, $1,400 to $2,000 a year. Apply on Form 1312.

## Science News Agency Founded

The establishment of an organization for the purpose of familiarizing the general reading public with the progress of scientific research has been announced at the offices of the National Research Council.

The new organization, to be known as "Science Service," has been substantially endowed and is chartered as a non-profit-making corporation. Its control is vested in a board of trustees composed of ten scientists and five journalists. The National Academy of Sciences, the American Association for the Advancement of Science and the National Research Council each elects three trustees. The personnel of the first board of trustees is announced as follows:

A. A. Noyes, director of chemical research, California Institute of Technology, Pasadena; R. A. Millikan, professor of physics, University of Chicago; John C. Merriam, president of the Carnegie Institution of Washington; D. T. MacDougal, director of the Desert Laboratory of the Carnegie Institution of Washington, Tucson, Ariz.; George I. Moore, director of the Missouri Botanical Gardens, St. Louis; J. McKeen Cattell, editor of *Science*, Garrison, N. Y.; George E. Hale, director of the Mount Wilson Observatory, Pasadena, Cal.; Vernon Kellogg, secretary of the National Research Council, Washington; R. M. Yerkes, chairman of the Research Information Service, National Research Council, Washington; E. W. Scripps, Miramar, Cal.; R. P. Scripps, Cleveland, Ohio; W. E. Ritter, director of the Scripps Institution for Biological Research of the University of California, La Jolla, Cal.; William Allen White, editor of the *Gazette*, Emporia, Kan.; Chester H. Rowell, Berkeley, Cal.; Edwin F. Gay, editor of the New York *Evening Post*.

The charter of the new organization is a wide one, authorizing Science Service to employ newspapers, periodicals, books, lectures, conferences, motion pictures and any similar educational agencies in the distribution of scientific information.

Edwin E. Slosson, for twelve years professor of chemistry at the University of Wyoming, for seventeen years literary editor of the *Independent* and author of "Creative Chemistry," "Easy Lessons in Einstein" and other popular science works, is to be the editor of Science Service. The manager is to be Howard Wheeler, formerly editor of the San Francisco *Daily News*, Pacific Coast manager of the Newspaper Enterprise Association, managing editor of *Harper's Weekly* and for five years editor of *Everybody's Magazine*.

The policy of the Service is to be one of co-operation rather than competition with existing press associations, news agencies and syndicates. It will aim to supply accurate and interesting articles on all branches of science and technology at the lowest possible cost.

Offices have been opened in the National Research Council Building, 1701 Massachusetts Ave., Washington.

## Chicago Chemists Club Annual Meeting

The members and friends of the Chicago Chemists Club gathered on the night of April 1 for the informal dinner, second annual business meeting and social evening at the quarters, 315 Plymouth Court. Besides being one of the many meetings which are doing so much to weld the professional men of Chicago through close personal friendships to the advancement of chemistry in this community, it was also the occasion of the second election of officers for the coming year.

The retiring president, dean and father of Chicago chemists, William Hoskins, gave a characteristic address on club affairs. He spoke about the quiet demonstration of the success of the club launched under difficulties over a year ago, touching briefly on the benefits of the weekly meetings and the momentum gathered over the period to be taken up and augmented by the incoming administration. The club in one short year has passed through the stage of infancy and grown to full young manhood. It must become more closely linked to the affairs of the community. While the membership is small, it is made up of professional men of the better type and the organization may well take a larger part in civic activities, to become eventually a power for better conditions in the Chicago district. There is great hope for the future and the support of all is needed in upholding the hands of the new officers to this end.

Paul Nicholas Leech, who was termed "the keystone of the arch," was called upon to describe the excellent work he had carried forward as chairman of the arrangements committee. A large part of the development of the club's progress is directly attributable to the tireless activity of Dr. Leech.

Reports by Messrs. Dunlap and Kawin showed the club to be shipshape as regards finances.

The officers for the coming year were next elected. Otto Eisenschiml, popular among chemists for his straightforward character and original wit, was unanimously elected president. L. W. Spring and W. Lee Lewis were chosen for first and second vice-presidents respectively. Paul Van Cleef was the unanimous choice for secretary, and Glenn H. Picard for treasurer. Carl S. Miner and J. R. Powell, stanch supporters of the better things for chemists, were made trustees.

The social feature of the evening was a profusely illustrated talk by Dr. Arthur J. Cramp of the American Medical Association on "The Dunes of Northern Indiana." Having been a dune fan for the past fifteen years, his description of this most remarkable territory held the deepest interest of the audience. A sea of sand covered with vegetation varying in kind from the tropical to the northern flora, these dunes merit the study of scientists and nature lovers.

## State-Owned Cement Plant in Dakota

South Dakota passed a law in 1919 authorizing a commission to survey the state for suitable raw materials for cement manufacture, and—in case it found that the state can successfully engage in the business—to locate, construct and operate a cement plant. A report to the Governor has recently been printed, signed by the commissioners, Paul E. Bellamy, W. J. Sharwood and C. M. Harrison, in which they note that the best and most acceptable cement materials are found in the Black Hills and that owing to cheap fuel and available water power cement can be manufactured at Rapid City and delivered to consumers in the state much cheaper than from any other point. A plant site and quarry land have accordingly been contracted for. On the basis of August, 1920, costs a plant of 2,000 bbl. daily capacity will cost approximately $2,000,000, in which first-quality cement can be manufactured for $1.48 per barrel, exclusive of interest on investment, amortization, and apparently of taxes and depreciation.

The commission's estimates follow:

| | |
|---|---|
| Cost of shale quarry equipment | $47,000 |
| Cost of limestone quarry equipment | 40,000 |
| Cost of cement mill | 1,570,000 |
| Cost of 200,000 bags | 70,000 |
| Cost of repair parts carried in stock | 50,000 |
| Operating capital | 223,000 |
| Total | $2,000,000 |

| Daily operating costs: | |
|---|---|
| Stripping in quarries | None |
| Shale quarry | $69.63 |
| Limestone quarry | 131.75 |
| Mill operating* | 2,462.14 |
| Charge against bags | 49.86 |
| Repair parts | 215.07 |
| Interest on operating capital | 36.61 |
| Total operating cost | $2,965.06 |
| Cost per barrel, f.o.b. plant | $1.48 |

*Electric power purchased at 1¼c. per kw.-hr.

In December, 1920, the date of the report, the commission was of the opinion that there would be a 50 per cent underproduction of cement during the next five years, and in view of the fact that no cement plant exists within 175 miles of the state boundaries the building of roads and other structures will undoubtedly be badly hampered. On Nov. 1, 1919, the price of cement was from $3 to $5 per barrel; the average wholesale rate delivered at each county seat on the basis of 1 barrel per capita was $3.53, without sacks. Adding the average freight rate to the above-itemized cost leads the commission to believe that a like service can be performed by a state-operated plant for $2.38 per barrel. The latter figure includes depreciation, amortization and interest.

## Lenroot Impressed at Edgewood

That the United States should maintain the lead it has obtained in the application of chemistry to war is the opinion of Senator Lenroot of Wisconsin. On returning from a recent visit to the Edgewood Arsenal Senator Lenroot made the following statement to the Washington correspondent of CHEMICAL & METALLURGICAL ENGINEERING:

"While chemical warfare is abhorrent to the minds of everyone, it ought to be realized that it constitutes a kind of warfare which cannot be insured against by treaty or other agreement. Its possibilities are limitless. It is absolutely necessary, as a matter of defense, that we not only keep abreast with other nations but that we stay in advance of them with respect to the use of chemicals in warfare. The best protection against such warfare is to be better prepared in its use than is any other nation. If we are thus prepared there probably never will be occasion to employ it.

"I was very much impressed with Edgewood Arsenal, especially with the laboratory and the work going on there. I shall favor the continuance of research and development work in this branch of the military service."

In addition, Senator Lenroot had the following to say about the Muscle Shoals development:

"I do not think anything should be done at Muscle Shoals for the next two or three years. I never have taken the position that we should adopt the policy of complete abandonment. It may be that when costs come down it would be well to take up the development again. If it is done, however, it should be only upon the assurance that it would be a good business proposition for the Government. As a military precaution I think the nitrate plants and the big steam power plant should be kept in standby condition. This can be done at comparatively little cost."

## New Jersey Clay Workers Hold Dinner in Honor of Ceramic School Designers

As a result of a contest recently held for a suitable design for the new ceramic building to be erected at Rutgers College, New Brunswick, N. J., the New Jersey Clay Workers' Association and Eastern Section of the American Ceramic Society gave a dinner to all contestants at the New Packer House, Perth Amboy, N. J., on Friday evening, April 1.

The prize contest was carried out under the auspices of the National Terra Cotta Society, which offered $300 in prizes for a suitable design for the facade of the new structure, divided into a first prize of $200 and second prize of $100. Fourteen persons entered the competition, the winners being E. W. Moell, Rocky Hill, N. J., and S. R. Audsley, Perth Amboy, both employees of the Atlantic Terra Cotta Co., who received the first and second prizes respectively.

Charles Howell Cook, president of the Cook Pottery Co., Trenton, N. J., acted as toastmaster at the dinner. The speeches dealt with the work connected with the new ceramic school building, for which a state appropriation has been secured, and the broad possibilities for development in the ceramic industry in the state. Among the speakers were: Abel Hansen, head of the Fords Porcelain Works, Perth Amboy; State Senator Thomas Brown; E. V. Eskesen, president New Jersey Terra Cotta Co.; Charles A. Bloomfield, head of the Bloomfield Clay Co.; George H. Brown, director department of ceramics, Rutgers College; Charles W. Crane, the Crossman Co., South Amboy; Roy H. Minton, General Ceramics Co.; Leslie Brown, Lenox, Inc.; D. P. Forst, Robertson Art Tile Co.; Andrew Faltz, Lambertville Pottery Co.. and Charles T. H. Phillips, head of the Sneyd Enameled Brick Co., Trenton.

## Prince of Monaco to Receive Agassiz Medal

An address on his oceanic researches by the Prince of Monaco will be one of the features of the meeting of the National Academy of Sciences which will be held in Washington April 25 to 27. On that occasion the Prince is to receive the Alexander Agassiz medal. The only previous award of this prize was to Dr. Johan Hjort.

## Domestic Potash Producers Discouraged

Despite the fact that there is reason to believe the Ways and Means Committee will approve an import duty of 50c. a unit on potash, representatives in Washington of the domestic potash industry take a gloomy view of the situation. As a result of the intense competition which has sprung up between the French and the Germans it now appears that 50c. a unit will not afford adequate protection.

In their efforts to capture the American market, representatives of the French and of the German producers are said to be making heavy concessions in price. This is especially the case when a five-year contract can be arranged. The French are now in a position to produce on a large scale. Despite the fact that stocks of potash in this country already are large, the French are continuing to build up their reserves here. German stocks have reached the point where little additional potash is being imported from that country.

It is believed that genuine competition between the Germans and French will continue as long as the French properties are under the direct control of the government. It now seems certain, it is stated, that the government will buy in the properties and then will lease them to private companies for operation. Once this takes place it is regarded as almost certain that the present ruinous type of competition will end, if there is not an understanding as to prices.

## Dr. F. G. Hopkins to Receive Chandler Medal

At a meeting to be held in Havemeyer Hall, Columbia University, at 8:15 p.m. Monday, April 18, the Chandler Medal will be presented to Frederick Gowland Hopkins, F.R.C.P., F.R.S., F.I.C., F.C.S., professor of biological chemistry, Cambridge University, in order to recognize publicly his pioneer and very valuable work in the study of food accessories, such as vitamines. Dr. Hopkins will speak on "Newer Aspects of the Nutrition Problem."

## Co-operative Work in Ceramics

Plans are being developed for intensive co-operative work between the Bureau of Mines and the Bureau of Standards, Washington, D. C., and the national brick and tile associations relative to investigations and experiments in the manufacture of burned clay building products. A fund is to be provided for carrying out the work, which for the most part will embody improved methods of production and the solution of fundamental problems encountered in this branch of manufacture. The associations interested in the movement include the Face Brick Manufacturers' Association, the American Common Brick Manufacturers' Association, the National Paving Brick Manufacturers' Association and the Hollow Building Tile Manufacturers' Association.

# Book Reviews

RAPID METHODS FOR THE CHEMICAL ANALYSIS OF SPECIAL STEELS, STEEL-MAKING ALLOYS, THEIR ORES AND GRAPHITES. By *Charles Morris Johnson*, Ph.M., Chief Chemist of the Park Works of the Crucible Steel Co. of America. Third edition, revised and enlarged. xi + 552 pp. New York: John Wiley & Sons, Inc., 1920. Price $6.

The new edition of this well-known text will be welcomed by all who are interested in the analysis of steel and steel-making materials. At the present time it is necessary for the steel analyst to be prepared to determine or guard against the interferences of about one-half of the elements of the periodic table. And who would say the end is yet? The present book provides for nearly all the probable cases of today. New material not found in either of the previous editions includes the analysis of chrome-vanadium and chromium steels; the complete analysis of tungsten ore;

tantalum and tungsten in ores, alloys and steels; arsenic in steel; zirconium in steel; the complete analysis of crude zirconia; oxygen and arsenic in copper; boron in iron; a new modification for the determination of phosphorus in the presence of vanadium using a faintly ammoniacal water solution of ammonium molybdate; the analysis of clays; a chapter on the micrographic examination of steel; notes on electrical laboratory furnaces and special refractories; the analysis of ferrocerium and cerium steel. A further addition of interest is the facsimile of the certificate of the new British standard chrome-vanadium steel and a comparison of the results on this steel from three American laboratories.

In addition to methods for analysis the book contains much information on the design and equipment of a steel-works laboratory and on grinding, sampling and the annealing and microscopic examination of steel. Tables of typical analyses of ores, slags, refractories and special alloys given throughout the book are convenient. The text is well illustrated.

There is a very noticeable opportunity to arrange the material given in this book according to some more simple or more evident scheme; the analytical methods arranged either on the basis of the elements being determined or according to the class of material being analyzed and the scattered portions on other subjects gathered together. While the author does not state that the methods described are confined to those in use at the Park Works of the Crucible Steel Co., yet it is so implied. Certainly in many instances references to recently published papers along lines related to the context are lacking—e.g., methods for oxygen in steel, nitrogen in steel, zirconium in steels and ores, electrometric methods. Complete details of the method for determining phosphorus in the presence of vanadium of pages 41 to 45 are needlessly duplicated in pages 318 to 323.

LOUIS JORDAN.

* * *

THE THERMIONIC VACUUM TUBE AND ITS APPLICATIONS. By *H. J. Van der Bijl*, M.A., Ph.D. 392 pp., illustrated. Price $5. New York: McGraw-Hill Book Co.

The publication of this book fills a need, experienced for a number of years by those not specialists in the field of conduction of electricity through gases, of a complete treatise on the theory and use of the vacuum tube as an amplifier and a detector of high-frequency electric currents. Although the principles employed in the operation of the vacuum tube as a rectifier, detector or amplifier have been described in detail in several treatises on the conduction of electricity through gases, or on the principles of electric wave telegraphy and telephony, this is the first adequate work devoted exclusively to that subject.

The book contains ten chapters, the first three of which are devoted to an introductory account of the properties of electrons, and of the conditions for their dislodgment from the atoms of gases and vapors and from solid substances. Chapter IV, on the physics of the thermionic valve—i.e., the two-electrode vacuum tube—discusses the general characteristics of the valve, while the effect of gases present in the tube is described in Chapter V. The principles of the use of the valve as a rectifier of alternating currents is described in Chapter VI. Chapter VII, the longest in the book, is devoted to a full description of the characteristics of the three-electrode vacuum tube and of the principles upon which its use as an amplifier is based. The use of the tube as an oscillation generator in a circuit having inductance and capacity is described in Chapter VIII, and Chapter IX is devoted to a description of its use as a detector and modulator of high-frequency electromagnetic waves as employed in radio telegraphy and telephony. Chapter X describes some of the miscellaneous applications of the thermionic tube, such, for instance, as its use as an electro-static voltmeter and as an ionization manometer, etc.

To those wishing to acquire a thoroughgoing acquaintance with one of the most important recent practical developments in the field of electromagnetism, this book is recommended.

C. C. VAN NUYS.

# Personal

H. W. BLANCHARD recently severed his relations with the chemical division of Procter & Gamble Co., Cincinnati, Ohio, and is now connected with the physics department of Purdue University, LaFayette, Ind.

HIPPOLYTE COPAUX, of the School of Industrial Physics and Chemistry of Paris; PIERRE LELAUDOUX, of the Tunisian Phosphate Co.; Dr. EUGENIO DONEGANI, of the Sicilian Sulphur Co., and GEORGES FLUSIN, of Grenoble, are in the United States making a study of the fertilizer situation.

Dr. COLIN G. FINK, organizer and for the past four years director of the research laboratories of the Chile Exploration Co., has resigned his post. Formerly Dr. Fink was in charge of research at the Edison Lamp Works, Harrison, N. J.

ALFRED N. FLINN, who was formerly with the Hydraulic Steel Co., Cleveland, Ohio, in the research department, has been reinstated as associate chemist at the Bureau of Standards, Washington, D. C., where previous to the past year he was engaged for nine years in the chemical testing of structural materials, but his present assignment is in chemical control of the manufacture of optical glass.

ARTHUR L. HALVORSEN, who has been connected with the Roessler & Hasslacher Chemical Co. for the past ten years as research chemist, resigned Jan. 1 to do consulting work in cyanide hydrometallurgy and industrial chemical research in general. He is located at 174 Water St., Perth Amboy, N. J.

Dr. DAVID R. MERRILL has resigned his position as research associate in the Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology, in order to accept a position in the research laboratory of the Union Oil Co. of California, Oleum, Cal.

Dr. R. F. RUTTAN, head of the department of chemistry at McGill University, has been administrative chairman of the Honorary Advisory Council for Scientific and Industrial Research in the absence of Dr. A. B. Macallum in the Orient.

HERVEY J. SKINNER, HERBERT L. SHERMAN and GUSTAVUS J. ESSELEN, JR., have associated themselves under the name of Skinner, Sherman & Esselen, Inc., and will act as consultants in matters pertaining to the application of chemistry and biology to industrial operations.

# Obituary

EDMUND COGSWELL CONVERSE, president of the National Tube Co. at the time of its merger into the U. S. Steel Corporation and later a director of the corporation, died suddenly of a heart attack on April 4, while at a hotel in Pasadena, Cal., where he and his wife had been living since February. His home was in Greenwich, Conn.

Dr. ERNST J. LEDERLE, the founder of the Lederle Laboratories and the Lederle Antitoxin Laboratories, which are now merged into the firm of Lederle & Provost, died on March 7, at Goshen, N. Y. Dr. Lederle was health commissioner of New York City during two administrations.

ELIE MILLETT, inventor of the Millett core oven and founder of the Millett Brass Co., died in Springfield, Mass., on Sunday, March 21. The Millett core oven was designed primarily to protect workmen in foundries from the intense heat from the old ovens and to eliminate the waste of heat when the charging door was opened. Mr. Millett acted on the theory that it was possible to have two doors on an oven instead of one and that it was also possible so to arrange the grates that the cores could be heated without opening both doors at once.

# Current Market Reports

## The Chemical and Allied Industrial Markets

NEW YORK, April 11, 1921.

One of the most hopeful signs noted in the week's chemical activities was the gradual removal of distressed spot stocks of many materials from weak second-hand holders. This condition is beginning to exert its influence in many quarters and while sellers are content to quote around lately prevailing levels, buyers are having a hard time purchasing special brand goods.

A few large producers reported some improvement in domestic trade. Although the increase was not very noticeable, there was more steadiness and expansion than at any time since the beginning of the year. It seems reasonable to assume that the quiet absorption of resale goods will eventually make itself felt in first-hand quarters. With any signs of real buying, the spot market will recover very easily. The dormant buying movement since last fall has created a very artificial condition where the short seller may encounter some difficulty with any noticeable revival.

Special standard brands of *caustic soda* were in demand and where inquiries were heard at former quotations, buyers experienced much difficulty in obtaining any round lots. Resale standard *bichromate of soda* showed an extremely firmer tendency on several occasions.

### GENERAL CHEMICALS

The *acetic acid* market continued unsettled, although tending toward the stronger end. Producers have held their prices on a fairly firm basis at former levels. The low prices are still quoted nominally, but it is generally known that deliveries are greatly delayed. The resale market is practically devoid of supplies, although an occasional odd lot is sold at former resale price levels. Quotations from leading manufacturers are based on 2½@3c. per lb. for the 28 per cent and 10@11c. for the glacial. A reduction in some directions has brought *nitric acid* down to a price basis of 6½@7½c. per lb. for the 40 deg. and 7½@8½c. for the 42 deg. Prices on *sulphuric acid*, 66 deg., in tank cars are quoted at $19@$20 per ton f.o.b. works. It is understood that with the present weakness of sulphur, a firm order would bring about price concessions. *Ammonium carbonate* prices in some quarters are quoted firm at 9½c. per lb. Offers elsewhere are heard as low as 7½c. for imported material. Demand has been exceedingly slow, so that there is no definite agreement between sellers.

The market on *ammonium chloride* continues in an unsettled state with spot stocks moderate in the absence of any noted demand. Importers are doubtful as to the future and domestic producers are still firm in their prices. Imported white granular is quoted at 7@7½c. per lb. as against 10@10½c. by domestic makers. Manufacturers of *ammonium sulphate* are holding their prices at $2.90@$3 per 100 lb. in bulk lots f.o.b. works. Spot material in distressed hands is quoted at $2.75@$2.90 per 100 lb. f.a.s. steamer, in double bags. Lack of demand has forced down prices to a decided extent. *Bleaching powder* has remained in the same unsettled position. Makers are quoting $2.75 per 100 lb. f.o.b. works, while the spot resale market is quoted at $2.50@$2.60. Prices on *copperas* are lower with the bulk quoted at 75c. per 100 lb. f.o.b. works. Quotations range upward to $1.25 per 100 lb., according to the package and delivery.

The *caustic potash* market is stagnant with resale offerings still heard at the former levels of 9½@10½c. per lb. for reshipped American material. Makers' prices are meaningless in the presence of heavy stocks of spot goods and the absence of demand. Domestic producers have reduced the price of *sodium chlorate* and are now offering at 8½c. per lb. for any quantity. Resale lots of *caustic soda* were generally quoted at $3.65 per 100 lb. ex-store and $3.75 f.a.s. Odd lots could possibly be purchased at $3.60, but most sellers were not eager to quote as low as this level on standard material. The absence of any large inquiries gave the market a tame appearance, although the undertone remained quite steady. It was said to be doubtful if more than odd lots of domestic light *soda ash* could be bought below $1.95@$2 per 100 lb. in single bags, spot N. Y. Imported material was offered at $1.90 and sales were recorded at this figure. Barrels were well held at $2.20@$2.25 per 100 lb. Trading in general was quiet with offerings small. Dense ash was held at 10c. per 100 lb. above the level.

*Bichromate of soda* dealers maintained the spot market at 7¾c. per lb. in most directions, although it was intimated that a few odd lots might be purchased down to 7½c. Offerings were not heavy, but there was still enough material on hand to take care of the prevailing inquiry. Consumers are apparently content to restrict their operations to actual wants only. Strength in copper metal has strengthened the market for *copper sulphate*. Leading producers have made no revision in prices, but the market looks firmer and there are indications that buyers are taking more interest. Demand for domestic use is moderate, but the insecticide trade has not covered and improvement in business is expected from this source of consumption. Standard 99 per cent large crystals are quoted by first hands at 5¾c. per lb. in carlots and small crystals, 98½-99 per cent, at 5⅝c. Odd lots of miscellaneous brands are on the market in moderate supply at 5½c. per lb. and possibly lower on firm business.

The following is a comparative list of miscellaneous chemicals since 1914:

| Article | 1921 | 1918 | 1914 |
|---|---|---|---|
| Acetone, lb. | $0.13 | $0.34 | $0.10 |
| Acetic acid, 100 lb. | 1.75 | 6.50 | 1.50 |
| Ammonia alum, lb. | 0.04 | 0.08 | 0.01½ |
| Potash alum, lb. | 0.05½ | 0.11 | .... |
| Ammonia carbonate, lb. | 0.09 | 0.12 | .... |
| Ammonia aqua, 26 deg., lb. | 0.07 | 0.10 | 0.02 |
| Ammonia sulphate, 100 lb. | 2.75 | .... | 2.50 |
| Arsenic, white powder, lb. | 0.08 | 0.11 | 0.03 |
| Arsenic, red, lb. | 0.12 | 0.47 | 0.05 |
| Bleaching powder, lb. | 0.02½ | 0.07 | 0.01½ |
| Blue vitriol, lb. | 0.05½ | 0.10 | 0.04½ |
| Bichromate soda, lb. | 0.07½ | 0.20 | 0.04½ |
| Bichromate potash, lb. | 0.12½ | 0.45 | .... |
| Borax, lb. | 0.06½ | 0.09 | 0.04 |
| Caustic potash, 88-92%, lb. | 0.09½ | 0.75 | 0.04 |
| Carbon tetrachloride, lb. | 0.10 | 0.70 | .... |
| Chlorate Potash, lb. | 0.08 | 0.35 | 0.07 |
| Citric acid, lb. | 0.47 | 0.95 | 0.54 |
| Cream tartar, lb. | 0.30 | 0.65 | 0.23 |
| Cyanide soda, lb. | 0.20 | 0.32 | .... |
| Epsom salts, 100 lb. | 2.25 | 3.50 | 0.75 |
| Formaldehyde, lb. | 0.15 | 0.22 | 0.08 |
| Glycerine, C.P., lb. | 0.17½ | 0.55 | 0.19 |
| Lime acetate, lb. | 0.01½ | 0.04 | 0.01½ |
| Oxalic acid, lb. | 0.16½ | 0.45 | 0.06 |
| Phenol, lb. | 0.11 | 0.40 | 0.07 |
| Permanagnate potash, lb. | 0.35 | 2.00 | 0.08 |
| Prussiate soda, lb. | 0.12½ | 0.55 | 0.11 |
| Prussiate potash, red, lb. | 0.48 | 0.90 | .... |
| Prussiate potash, yellow, lb. | 0.26 | 2.25 | 0.12 |
| Rochelle salt, lb. | 0.27 | 0.47 | 0.16 |
| Soda ash, 100 lb. | 1.95 | 2.75 | 0.75 |
| Soda, caustic, solid, 100 lb. | 3.65 | 5.25 | 1.80 |
| Sulphur flour, 100 lb. | 2.25 | 3.25 | 2.00 |
| Sal ammoniac, gran., lb. | 0.07 | 0.25 | 0.06½ |
| Tartaric acid, lb. | 0.36 | 0.85 | 0.30 |

### COAL-TAR PRODUCTS

Trading in the coal-tar products marked during the past week has shown a tendency to expand in some quarters, but although sales are more numerous, the business is of a very small character, for spot lots, with nothing in the way of future requirements being considered. Production has been generally curtailed and covers a majority of the items on the list. Resale stocks in warehouses are not believed to be large and those close to the heart of trading expressed the opinion that the turning point in the dullness of the market has been passed. Prices have been steadily reduced and labor is gradually drifting back to work at revised schedules. Reports of developments from textile centers are very encouraging and the industry looks forward to a radical improvement in the very near future.

Crude products are moving in better volume and the tone of the market is steady. *Benzene* and *toluene* are not expected to show any further easiness in prices, while on the other hand any material increase would create a tight market in a short time. *Napththalene* is in easy supply and prices vary according to seller, with the flake at 8@9c. per lb. and the ball at 9½@10c.

Intermediates are showing a much steadier tendency with sellers not trying to push business and shading only on

firm orders. *Aniline oil, beta naphthol* and *paranitraniline* are steady, with prices unchanged during the past week. Supplies of *nitro benzene* are reported as easy in most directions and figures range from 12@15c. per lb. Consumers are showing little interest in the market and only a light routine movement is recorded. The volume of trading in *ortho nitrophenol* during the period was said to be at a minimum. Supplies are available in some quarters on the basis of 75@80c. per lb. The market for *para phenylenediamine* has been quite steady during the week and a moderate volume of trading has been transacted on the basis of $1.95@$2 per lb. There has been no improvement reported in the market for *toluene*. The demand has been very light and supplies are fairly easy. Prices quoted by producers range from 28@31c. per gal., depending on quantity, with second-hand offerings slightly under these figures. Resale stocks of *para nitraniline* have been pretty well cleaned out and while it may be possible to find an occasional odd lot as low as 85c. per lb. the market has practically passed to first hands at 95c.@$1.05 per lb., according to quantity. Demand has been quite slow. Offers of *dimethylaniline* on spot are heard at 48@50c. per lb. from second hands, with producers quoting 50@60c. per lb. Business has been limited to small lots.

### Miscellaneous Materials

As far as prices are concerned very little change was evident in the miscellaneous materials market outside of a slightly firmer feeling in mostly all quarters. The demand in general is as yet confined principally to limited lots, but it was noted that transactions were more frequent. Indications pointed to an early increase in activity. Spring operations in the paint field are being pushed and relief is in sight. *Barytes* held steady and practically unchanged. *Blanc fixe* changed hands quite freely, but mostly in small lots. *Litharge* remained in much the same position. *Zinc oxide* figures held steady in all quarters.

While there continued to be little in the way of large-lot trading in *barytes*, a regular demand is heard for moderate amounts and on the whole a better feeling pervades this market. Prices held steady in all quarters with little inclination noted to change. The prime white remains quoted at $30@$35 per ton. Offerings of *blanc fixe* were plentiful but not pressed and prices held steady. The general asking price is 4¾c. per lb., but intimations were made that bids of 4½c. would most likely be accepted. Numerous small lot sales were reported by factors, while on large lots very little activity was recorded. A firm tone prevailed in the *litharge* market, although trading in general was limited and spot stocks plentiful. First hands quote firm at 8¾c. per lb. as an inside figure. Leading producers of *zinc oxide* reported nothing new and stated that the same routine inquiry continued to be received. Prices remained firm at 8½@9½c. per lb. for the XX grade.

## The Chicago Market

CHICAGO, April 8, 1921.

Business in heavy chemicals showed a decided improvement during the past week, most factors reporting an unusually large volume of small orders. It is evident that supplies in consumers' hands are getting low and that they will soon be back in the market again.

In general the list remained firm, the most notable exception being c.p. *glycerine*, which was reduced by refiners to 17c. per lb., bulk basis. This marks the lowest level reached in seven or eight years. There is some demand for *soda ash*, which is quoted at 2½@3c. in a small way. *Caustic soda* is firm, the ground being offered at 4¾c. per lb. in barrels, and the solid at 4¼c. in drums. The inquiry for *formaldehyde* is good, and a considerable volume of business is reported at 16@16½c. per lb. Sales of *ammonium chloride*, white gran., are few, and lower prices are expected. Quotations vary from 11½@12½c., depending upon the quantity and the seller. The demand for *aluminum sulphate*, iron free, is rather light and the material is offered freely at 3½@4c. per lb. A fair inquiry is noted for *carbon bisulphide*, the price remaining firm at 8@8½c. in single drum lots. *Carbon tetrachloride* is not moving as well and is offered at 11c., in the large drums.

The lower prices in the New York market on *lead acetate*, white crystals, have not been reflected here and local dealers continue to quote 15c. per lb. in casks. They report a good volume of business and show little tendency to shade present prices. There is a small quantity of *potassium bichromate* in the market at 16c., but better prices are obtainable on material for prompt shipment from the East. *Potassium permanganate* is lower, spot goods being offered at 45@50c. per lb. As this material is offered for prompt shipment from abroad at much lower prices, the movement is slow and is confined to small packages. *Sodium bichromate* is firmer, the best price heard being 9c.; while some holders are asking as high as 11c.

Prices on *acetic acid* are unchanged, the glacial being offered at $11 per 100 lb. and the 28 per cent at 2¾@3c. The demand for *citric acid* has increased and prices are firm at 47@49c. per lb. *Sulphuric acid* is unchanged and manufacturers continue to ask $19@$20 per ton for the 66 deg.

### Vegetable Oils

Unusually quiet conditions continue to prevail in this branch of the trade, and there is little or no demand to speak of. Buyers are holding off and there is a strong feeling in some quarters that several of the items will go lower, regardless of the talk of better prices. *Coconut oil* is quiet, the prevailing quotations running from 10@10½c. per lb. for single barrels. There is a slightly better demand for *linseed oil*, and dealers are asking 67@69c. per gal. in lots of 1 to 5 bbl.

### Naval Stores

In general this market is dull and the only feature worth mentioning is the advance in *turpentine*. While it is still possible to secure small lots in some quarters at 60c. per gal., most factors have advanced their prices to 62c. *Rosin* continues as dull as ever, with most buyers showing little or no interest and few sales being reported. The holders are asking around $7.25 for the WG grade, but this price could probably be shaded with a firm order.

### Coal-Tar Products

*Benzene* prices are lower, the new level being 28c. per gal. in drums for the 90 per cent and 30c. for the 100 per cent. There are a few small sales reported, but the demand is still far from satisfactory. *Naphthalene flakes* are moving in a small way and prices have been maintained at 9@10c. per lb.

## The Iron and Steel Market

PITTSBURGH, April 8, 1921.

The iron and steel market continues its uneventful career. There is perhaps a slight farther broadening in demand for steel products, through shipping instructions becoming somewhat more numerous, but the business is very largely in carload lots and shows how very modest the requirements of consumers are at this time. Part of the business received is in new orders, but a large part is in releases against orders previously suspended. Buyers are not covering their full requirements in all cases with these shipping instructions, there being many cases in which stocks on hand are simply being pieced out. The proper conclusion seems to be that the rate of actual consumption is in excess of the rate of producing and shipping, but it does not follow that the rate of consumption will continue after all the stocks in buyers' hands have been disposed of. There is the automobile industry, for instance, which is increasing in activity from week to week and is reducing its inventories, but the spring buying season for automobiles will be entirely over before the stocks are all liquidated, and the sale of automobiles may then decrease.

In recent weeks the steel industry has been disposed to look for an improvement in steel demand at some time in the future by there being a large increase in dwelling house construction, contingent upon revision of wage rates and working conditions in the building trades. Latest trends, however, suggest that possibly the so-called "housing shortage" will be solved in part by a decrease in the demand for houses as incomes are reduced or disappear, as families separated by the search for the highest paid job with the least work are reunited and as men go back to the farm.

Detroit shows a surplus of houses after ten years of a "housing shortage," while the latest count in Cleveland shows 2,100 unoccupied houses.

### Production

Pig-iron production is down to about 35 per cent of capacity, there having been a sharp further decrease in the past few weeks. Merchant furnace production is particularly low, but there is a question whether production of pig iron by steel works is not still in excess of the current consumption by the works, for an estimate commonly accepted in the trade is that the independent steel works are operating at about 20 per cent of capacity and the Steel Corporation at between 40 and 45 per cent, which would make a rate for the whole steel industry of about 30 per cent. Independent operations have not changed materially for several weeks, while the Steel Corporation's operations continue to decline, though at a much slower rate than in February and the early part of March. The corporation is still operating to a considerable extent upon orders and specifications received long ago. Its incoming business is largely in the form of releases against orders previously suspended, and thus the natural trend would be for the Steel Corporation's production to continue to decline until business in general revives. A rough guess would be that if production is now at about 30 per cent of capacity it will decline slightly more in the near future, then rising to a rate of 45 or 50 per cent late in the year. At some time in the future there will be, of course, reasonably full industrial activity, but on account of the 50 per cent increase in steel capacity that has occurred since 1914 it is not entirely certain that at that time there will be full activity for the steel industry as now constituted.

### Prices

There has been no material change in the independent market for steel products in the past week and no great change for several weeks. This steadiness may be due to the almost complete absence of inquiry for large lots, which would promise a fair operating rate for the mill or department that secured the order. The independents are getting simply small orders, which do not afford anything like an economical operation. In many cases there is less competition for a carload order than might be expected, because some mills do not have an operation scheduled for an early enough date to meet the requirements of the prospective buyer. The independent market on carload lots is quotable at 2c. for bars, 2.10c. for shapes and plates, 3.75c. for black sheets, 4.80c. for galvanized sheets and about $4 a ton off the standard list for pipe.

The Steel Corporation exhibits no intention of modifying its prices in the near future, its adherence to the Industrial Board price schedule being accepted by the trade now as a more natural thing than the trade was assuming a few weeks ago. Predictions as to when the corporation will reduce its prices have practically disappeared. It may be helpful to recall that during almost the entire period of more than a twelvemonth during which the corporation held its prices down to the Industrial Board schedule while the independents were charging higher prices there was continuous expectation that the corporation would advance its prices.

### Pig Iron and Coke

Pig iron displays no activity, and prices remain quotable at $25 for bessemer, malleable and foundry and $23 for basic, f.o.b. valley furnaces. Nearly all the independent coke operators in the Connellsville region have reduced wages to the scale of Nov. 10, 1917, involving on an average somewhat more than 30 per cent reduction from the former scale, which is still in force by the H. C. Frick Coke Co., the coke subsidiary of the Steel Corporation. On the inquiry for 500 tons of coke a day to a furnace at Portsmouth, Ohio, mentioned a week ago, it is understood the sale was made at not over $3.75, the delivery being over five or six weeks until the byproduct coking plant at Portsmouth can be got in operation. The $3.75 price is regarded as a close one even with the reduced wages now in force and little if any further liquidation in coke is to be expected. Coke sold at $18 to $19 last summer.

## General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

| | | Carlots | Less Carlots |
|---|---|---|---|
| Acetic anhydride | lb. | ..... – ..... | $0.40 – $0.45 |
| Acetone | lb. | $0.13 – $0.13½ | .13¾ – .14 |
| Acid, acetic, 28 per cent | 100 lbs. | 2.50 – 2.75 | 3.00 – 3.25 |
| Acetic, 56 per cent | 100 lbs. | 4.00 – 4.25 | 4.50 – 5.50 |
| Acetic, glacial, 99½ per cent, carboys, 100 lbs. | | 9.50 – 9.75 | 10.00 – 10.50 |
| Boric, crystals | lb. | .14½ – .15 | .15½ – .16 |
| Boric, powder | lb. | .15½ – .16½ | .17 – .18 |
| Citric | lb. | ..... – ..... | .47 – .50 |
| Hydrochloric | 100 lb. | 1.60 – 1.75 | 2.00 – 2.20 |
| Hydrofluoric, 52 per cent | lb. | .13 – .13½ | .14 – .14½ |
| Lactic, 44 per cent tech | lb. | .10 – .11 | .11½ – .12 |
| Lactic, 22 per cent tech | lb. | .04½ – .05½ | .06 – .07 |
| Molybdic, C. P | lb. | 4.00 – 4.50 | 4.50 – 5.00 |
| Muriatic, 20 deg. (see hydrochloric) | | ..... – ..... | ..... – ..... |
| Nitric, 40 deg | lb. | .06½ – .06¾ | .07 – .07¼ |
| Nitric, 42 deg | lb. | .07¼ – .07½ | .07¾ – .08¼ |
| Oxalic, crystals | lb. | .16½ – .17 | .18 – .19 |
| Phosphoric, Ortho, 50 per cent solution | lb. | .17 – .17½ | .18 – .19 |
| Picric | lb. | .30 – .32 | .35 – .40 |
| Pyrogallic, resublimed | lb. | ..... – ..... | 1.90 – 2.15 |
| Sulphuric, 60 deg., tank cars | ton | ..... – ..... | ..... – ..... |
| Sulphuric, 60 deg., drums | ton | ..... – ..... | 14.00 – 15.00 |
| Sulphuric, 66 deg., tank cars | ton | 19.00 – 20.00 | ..... – ..... |
| Sulphuric, 66 deg., drums | ton | 22.00 – 22.50 | 23.00 – 23.50 |
| Sulphuric, 66 deg., carboys | ton | ..... – ..... | ..... – ..... |
| Sulphuric, fuming, 20 per cent (oleum) tank cars | ton | 23.00 – 24.00 | ..... – ..... |
| Sulphuric, fuming, 20 per cent (oleum) drums | ton | 25.00 – 26.00 | 26.50 – 27.00 |
| Sulphuric, fuming, 20 per cent (oleum) carboys | ton | 32.00 – 35.00 | 40.00 – ..... |
| Tannic, U. S. P | lb. | ..... – ..... | 1.00 – 1.10 |
| Tannic (tech.) | lb. | .50 – .52 | .54 – .57 |
| Tartaric, crystals | lb. | ..... – ..... | .36 – .40 |
| Tungstic, per lb. of WO | lb. | ..... – ..... | 1.30 – 1.40 |
| Alcohol, Ethyl | gal. | ..... – ..... | 4.90 – 5.25 |
| Alcohol, Methyl (see methanol) | | ..... – ..... | ..... – ..... |
| Alcohol, denatured, 188 proof | gal. | ..... – ..... | .40 – .45 |
| Alcohol, denatured, 190 proof | gal. | ..... – ..... | .44 – .52 |
| Alum, ammonia lump | lb. | .04 – .04¼ | .04½ – .04¾ |
| Alum, potash lump | lb. | .05½ – .06 | .06½ – .07 |
| Alum, chrome lump | lb. | .13 – .13½ | .14 – .14½ |
| Aluminum sulphate, commercial | lb. | .02½ – .02½ | .02¾ – .03 |
| Aluminum sulphate, iron free | lb. | .03 – .03½ | .03½ – .03¾ |
| Aqua ammonia, 26 deg., drums (750 lb.) | lb. | .07 – .07½ | .07¾ – .08 |
| Ammonia, anhydrous, cyl. (100-150 lb.) | lb. | .30 – .32 | .33 – .35 |
| Ammonium carbonate, powder | lb. | .09 – .09½ | .10 – .11 |
| Ammonium chloride, granular (white salamoniac) (nominal) | lb. | .07 – .07¼ | .07½ – .09 |
| Ammonium chloride, granular (gray salammoniac) | lb. | .08½ – .08¾ | .09 – .09½ |
| Ammonium nitrate | lb. | .08 – .08½ | .09 – .10 |
| Ammonium sulphate | 100 lb. | 2.75 – 2.85 | 2.90 – 3.00 |
| Amylacetate | gal. | ..... – ..... | 4.00 – 4.25 |
| Amylacetate tech | gal. | ..... – ..... | 3.09 – 3.25 |
| Arsenic oxide, (white arsenic) powdered | lb. | .08 – .08½ | .09 – .10 |
| Arsenic, sulphide, powdered (red arsenic) | lb. | .12 – .12½ | .13 – .14 |
| Barium chloride | ton | 60.00 – 65.00 | 70.00 – 75.00 |
| Barium dioxide (peroxide) | lb. | .19 – .20 | .21 – .22 |
| Barium nitrate | lb. | .11 – .11½ | .12 – .12½ |
| Barium sulphate (precip.) (blanc fixe) | lb. | .04½ – .05 | .05½ – .06 |
| Bleaching powder (see calc. hypochlorite) | | ..... – ..... | ..... – ..... |
| Blue vitriol (see copper sulphate) | | ..... – ..... | ..... – ..... |
| Borax (see sodium borate) | | ..... – ..... | ..... – ..... |
| Brimstone (see sulphur, roll) | | ..... – ..... | ..... – ..... |
| Bromine | lb. | .40 – .41 | .42 – .45 |
| Calcium acetate | 100 lbs. | 1.60 – 2.00 | ..... – ..... |
| Calcium carbide | lb. | .04½ – .04¾ | .05 – .05½ |
| Calcium chloride, fused, lump | ton | 27.00 – 29.00 | 30.00 – 32.00 |
| Calcium chloride, granulated | lb. | .01½ – .01¾ | .02 – .02½ |
| Calcium hypochlorite (bleach'g powder) | 100 lb. | 2.40 – 2.60 | 2.75 – 3.00 |
| Calcium peroxide | lb. | ..... – ..... | 1.25 – 1.50 |
| Calcium phosphate, tribasic | lb. | ..... – ..... | .15 – .16 |
| Camphor | lb. | ..... – ..... | .65 – .68 |
| Carbon bisulphide | lb. | .07 – .07½ | .07½ – .08 |
| Carbon tetrachloride, drums | lb. | .10 – .10½ | .11 – .12 |
| Carbonyl chloride (phosgene) | lb. | ..... – ..... | .75 – 1.00 |
| Caustic potash (see potassium hydroxide) | | ..... – ..... | ..... – ..... |
| Caustic soda (see sodium hydroxide) | | ..... – ..... | ..... – ..... |
| Chlorine, gas, liquid-cylinders (100 lb.) | lb. | .08 – .09 | .09½ – .10 |
| Chloroform | lb. | ..... – ..... | .38 – .40 |
| Cobalt oxide | lb. | ..... – ..... | 3.00 – 3.10 |
| Copperas (see iron sulphate) | | ..... – ..... | ..... – ..... |
| Copper carbonate, green precipitate | lb. | .23 – .24 | .25 – .27 |
| Copper cyanide | lb. | ..... – ..... | .50 – .62 |
| Copper sulphate, crystals | lb. | .05½ – .05¾ | .06 – .06¼ |
| Cream of tartar (see potassium bitartrate) | | ..... – ..... | ..... – ..... |
| Epsom salt (see magnesium sulphate) | | ..... – ..... | ..... – ..... |
| Ethyl Acetate Com. 85% | gal. | ..... – ..... | .90 – 1.00 |
| Ethyl Acetate pure (acetic ether 98% to 100%) | | ..... – ..... | ..... – ..... |
| Formaldehyde, 40 per cent | lb. | .15 – .15½ | .15½ – .16 |
| Fusel oil, ref | gal. | ..... – ..... | 3.50 – 3.75 |
| Fusel oil, crude | gal. | ..... – ..... | 2.00 – 2.25 |
| Glauber's salt (see sodium sulphate) | | ..... – ..... | ..... – ..... |
| Glycerine, C. P. drums extra | lb. | ..... – ..... | .17½ – .18½ |
| Iodine, resublimed | lb. | ..... – ..... | 3.75 – 3.85 |
| Iron oxide, red | lb. | ..... – ..... | .10 – .20 |
| Iron sulphate (copperas) | 100 lb. | .75 – 1.00 | 1.10 – 1.25 |
| Lead acetate | lb. | ..... – ..... | .11½ – 13½ |
| Lead arsenate, powdered | lb. | .08½ – .09 | .09½ – .10 |
| Lead nitrate | lb. | ..... – ..... | .15 – .20 |
| Litharge | lb. | .08½ – .09 | .09½ – .10 |
| Lithium carbonate | lb. | ..... – ..... | 1.25 – ..... |
| Magnesium carbonate, technical | lb. | .10½ – .11 | .11½ – .12 |
| Magnesium sulphate, U. S. P | 100 lb. | 2.75 – 3.00 | ..... – ..... |
| Magnesium sulphate, technical | 100 lb. | ..... – ..... | 2.25 – 2.50 |
| Methanol, 95% | gal. | ..... – ..... | .75 – .77 |
| Methanol, 97% | gal. | ..... – ..... | .78 – .82 |
| Nickel salt, double | lb. | ..... – ..... | .13 – .13½ |
| Nickel salt, single | lb. | ..... – ..... | .14 – .14½ |
| Phosgene (see carbonyl chloride) | | ..... – ..... | ..... – ..... |
| Phosphorus, red | lb. | .45 – .46 | .47 – .50 |
| Phosphorus, yellow | lb. | ..... – ..... | .35 – .37 |
| Potassium bichromate | lb. | .12 – .12¼ | .12½ – .13 |

| | | Carlots | Less Carlots |
|---|---|---|---|
| Potassium bitartrate (cream of tartar) | lb. | $ .. – $.... | $0.30 –$0.35 |
| Potassium bromide, granular | lb. | ..... – ..... | .40 – .40 |
| Potassium carbonate, U. S. P. | lb. | .35 – .40 | .45 – .50 |
| Potassium carbonate, crude | lb. | .06½ – .07 | .08 – .09 |
| Potassium chlorate, crystals | lb. | .08 – .10 | .11 – .15 |
| Potassium cyanide | lb. | ..... – ..... | .40 – .45 |
| Potassium hydroxide (caustic potash) | lb. | .09½ – .10 | .10½ – .11½ |
| Potassium muriate | ton | 57.00 – 65.00 | ..... – ..... |
| Potassium iodide | lb. | ..... – ..... | 2.75 – 3.00 |
| Potassium nitrate | lb. | .09½ – .09½ | .10 – .12¼ |
| Potassium permanganate | lb. | .35 – .37 | .39 – .40 |
| Potassium prussiate, red | lb. | .48 – .50 | .51 – .53 |
| Potassium prussiate, yellow | lb. | .26 – .27 | .28 – .29 |
| Potassium sulphate (powdered) | per unit | ..... – ..... | 2.15 – 2.25 |
| Rochelle salts (see sodium potas tartrate) | | ..... – ..... | ..... – ..... |
| Salammoniac (see ammonium chloride) | | ..... – ..... | ..... – ..... |
| Sal soda (see sodium carbonate) | | ..... – ..... | ..... – ..... |
| Salt cake | ton | ..... – ..... | 32.00 –34.00 |
| Silver cyanide | oz. | ..... – ..... | 1.30 – 1.35 |
| Silver nitrate | oz. | ..... – ..... | .39 – .40 |
| Soda ash, light | 100 lb. | 1.95 – 2.10 | 2.15 – 2.40 |
| Soda ash, dense | 100 lb. | 2.20 – 2.30 | 2.40 – 2.60 |
| Sodium acetate | lb. | .04½ .05 | .05½ – .06 |
| Sodium bicarbonate | 100 lb. | 2.50 – 2.60 | 2.70 – 3.00 |
| Sodium bichromate | lb. | .07¾ – .08 | .08½ – .08½ |
| Sodium bisulphate (nitre cake) | ton | 5.00 – 5.25 | 5.50 – 6.50 |
| Sodium bisulphite powdered, U.S.P. | lb. | .05¼ – .05½ | .05½ – .06 |
| Sodium borate (borax) | lb. | .05½ – .06¼ | .07 – .07½ |
| Sodium carbonate (sal soda) | 100 lb. | 1.90 – 2.00 | 2.25 – 2.50 |
| Sodium chlorate | lb. | .08½ – .09 | .09½ – .10 |
| Sodium cyanide, 96-98 per cent | lb. | .19 – .20 | .21 – .30 |
| Sodium fluoride | lb. | .12 – .12½ | .13 – .14 |
| Sodium hydroxide (caustic soda) | 100 lb. | 3.65 – 3.75 | 3.80 – 4.00 |
| Sodium hyposulphite | lb | ..... – ..... | .03½ – .04 |
| Sodium nitrate | 100 lb. | 2.60 – ..... | 2.70 – ..... |
| Sodium nitrite | lb. | .06 – .06½ | .06½ – .07 |
| Sodium peroxide, powdered | lb. | .25 – .26 | .27 – .30 |
| Sodium phosphate, dibasic | lb. | .04½ – .04¾ | .05 – .05½ |
| Sodium potassium tartrate (Rochelle salts) | lb. | ..... – ..... | .27 – .28 |
| Sodium prussiate, yellow | lb. | .12½ – .12¾ | .13 – .13½ |
| Sodium silicate, solution (40 deg.) | lb. | 1.25 – 1.35 | 1.40 – 1.50 |
| Sodium silicate, solution (60 deg.) | lb. | .03 – .03½ | .03½ – .03¾ |
| Sodium sulphate, crystals (Glauber's salt) | 100 lbs. | 1.75 – 2.00 | 2.25 – 2.50 |
| Sodium sulphide, fused, 60-62 per cent (cone.) | lb. | .05 – .05½ | .05½ – .06 |
| Sodium sulphite, crystals | lb. | .04 – .04½ | .04½ – .05 |
| Strontium nitrate, powdered | lb. | .15 – .15½ | .16 – .17 |
| Sulphur chloride, red | lb. | .07 – .07½ | .07½ – .08 |
| Sulphur, crude | ton | 20.00 – 22.00 | ..... – ..... |
| Sulphur dioxide, liquid, cylinders ext a | lb. | .08 – .08½ | .09 – .10 |
| Sulphur (sublimed), flour | 100 lb. | ..... – ..... | 2.25 – 3.10 |
| Sulphur, roll (brimstone) | 100 lb. | ..... – ..... | 2.00 – 2.75 |
| Tin bichloride, 50 per cent | lb. | .18 – .19 | ..... – ..... |
| Tin oxide | lb. | ..... – ..... | .40 – .42 |
| Zinc carbonate, precipitate | lb. | .16 – .18 | .19 – .20 |
| Zinc chloride, gran | lb. | .11 – .11½ | .11½ – .12 |
| Zinc cyanide | lb. | .45 – .49 | .50 – .60 |
| Zinc dust | lb. | .12 – .13 | .13½ – .14 |
| Zinc oxide, XX | lb. | .08½ – .09 | .09½ – .10 |
| Zinc sulphate | lb. | .03¼ – .03½ | .04 – .05 |

## Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

| | | |
|---|---|---|
| Alpha-naphthol, crude | lb. | $1.15 — $1.25 |
| Alpha-naphthol, refined | lb. | 1.45 — 1.50 |
| Alpha-naphthylamine | lb. | .38 — .40 |
| Aniline oil, drums extra | lb. | .20 — .26 |
| Aniline salts | lb. | .26 — .29 |
| Anthracene, 80% in drums (100 lb.) | lb. | .75 — 1.00 |
| Benzaldehyde U.S.P. | lb. | 1.00 — 1.50 |
| Benzidine, base | lb. | .93 — 1.00 |
| Benzidine sulphate | lb | .75 — .80 |
| Benzoic acid, U.S.P. | lb. | .65 — .70 |
| Benzoate of soda, U.S.P. | lb. | .65 — .70 |
| Benzene, pure, water-white, in drums (100 gal.) | gal. | .27 — .32 |
| Benzene, 90%, in drums (100 gal.) | gal. | .25 — .28 |
| Benzyl chloride, 95-97%, refined | lb. | .28 — .30 |
| Benzyl chloride, tech | lb. | .25 — .27 |
| Beta-naphthol benzoate | lb. | 3.50 — 4.00 |
| Beta-naphthol, sublimed | lb. | .70 — .75 |
| Beta-naphthol, tech | lb. | .33 — .45 |
| Beta-naphthylamine, sublimed | lb. | 2.25 — 2.40 |
| Cresol, U. S. P., in drums (100 lb.) | lb. | .16 — .18 |
| Ortho-cresol, in drums (100 lb.) | lb. | .25 — .27 |
| Cresylic acid, 97–99%, straw color, in drums | gal. | .90 — .95 |
| Cresylic acid, 95-97%, dark, in drums | gal. | .85 — .90 |
| Cresylic acid, 50%, first quality, drums | gal. | .55 — .60 |
| Dichlorbenzene | lb. | .06 — .09 |
| Diethylaniline | lb. | 1.25 — 1.30 |
| Dimethylaniline | lb. | .48 — .55 |
| Dinitrobenzene | lb. | .30 — .32 |
| Dinitroclorbenzene | lb. | .25 — .30 |
| Dinitronaphthalene | lb. | .33 — .35 |
| Dinitrophenol | lb. | .40 — .45 |
| Dinitrotoluene | lb. | .25 — .27 |
| Dip oil, 25%, tar acids, car lots, in drums | gal. | .38 — .40 |
| Diphenylamine | lb. | .60 — .70 |
| H-acid | lb. | 1.30 — 1.50 |
| Meta-phenylenediamine | lb. | 1.20 — 1.25 |
| Monochlorbenzene | lb. | .14 — .16 |
| Monoethylaniline | lb. | 1.90 — 2.00 |
| Naphthalene crushed, in bbls. (250 lb.) | lb. | .08 — .08½ |
| Naphthalene, flake | lb. | .08½ — .09½ |
| Naphthalene, balls | lb. | .09½ — .10½ |
| Naphthionic acid, crude | lb. | .70 — .75 |
| Nitrobenzene | lb. | .12 — .15 |
| Nitro-naphthalene | lb. | .30 — .35 |
| Nitro-toluene | lb. | .16 — .18 |
| Ortho-amidophenol | lb. | 3.20 — 3.75 |
| Ortho-dichlor-benzene | lb. | .15 — .20 |
| Ortho-nitro-phenol | lb. | .75 — .80 |
| Ortho-nitro-toluene | lb. | .17 — .20 |
| Ortho-toluidine | lb. | .25 — .30 |
| Para-amidophenol, base | lb. | 1.90 — 2.00 |
| Para-amidophenol, HCl | lb. | 2.10 — 2.20 |
| Para-dichlorbenzene | lb. | .15 — .20 |
| Paranitroaniline | lb. | .90 — 1.05 |
| Para-nitrotoluene | lb. | .90 — 1.05 |
| Para-phenylenediamine | lb. | 1.95 — 2.00 |
| Para-toluidine | lb. | 1.25 — 1.60 |
| Phthalic anhydride | lb. | .50 — .60 |
| Phenol, U. S. P., drums (dest.), (240 lb.) | lb. | .11 — .13 |
| Pyridine | gal. | 2.00 — 3.50 |
| Resorcinol, technical | lb. | 1.85 — 2.00 |
| Resorcinol, pure | lb. | 2.30 — 2.50 |
| Salicylic acid, tech., in bbls. (110 lb.) | lb. | .22 — .23 |
| Salicylic acid, U. S. P. | lb. | .24 — .26 |
| Salol | lb. | .85 — .95 |
| Solvent naphtha, water-white, in drums, 100 gal. | gal. | .25 — .28 |
| Solvent naphtha, crude, heavy, in drums, 100 gal. | gal. | .14 — .16 |
| Sulphanilic acid, crude | lb. | .30 — .35 |
| Tolidine | lb. | 1.35 — 1.45 |
| Toluidine, mixed | lb. | .40 — .45 |
| Toluene, in tank cars | gal. | .25 — .28 |
| Toluene, in drums | gal. | .28 — .31 |
| Xylidines, drums, 100 gal. | lb. | .40 — .45 |
| Xylene, pure, in drums | gal. | .42 — .45 |
| Xylene, pure, in tank cars | gal. | .45 — ..... |
| Xylene, commercial, in drums, 100 gal. | gal. | .33 — .35 |
| Xylene, commercial, in tank cars | gal. | .30 — ..... |

## Waxes

Prices based on original packages in large quantities.

| | | |
|---|---|---|
| Beeswax, refined, dark | lb. | $0.24 — $0.26 |
| Beeswax, refined, light | lb. | .27 — .28 |
| Beeswax, white pure | lb. | .40 — .45 |
| Carnauba, Flora | lb. | .68 — .70 |
| Carnauba, No. 2, North Country | lb. | .30 — .32 |
| Carnauba, No. 3, North Country | lb. | .18 — .19 |
| Japan | lb. | .19½ — .19½ |
| Montan, crude | lb. | .07 — .08 |
| Paraffine waxes, crude match wax (white) 105-110 m.p. | lb. | .04 — ..... |
| Paraffine waxes, crude, scale 124-126 m.p. | lb. | .03 — ..... |
| Paraffine waxes, refined, 118-120 m.p. | lb. | .04 — .04½ |
| Paraffine waxes, refined, 125 m.p. | lb. | .04½ — .04¾ |
| Paraffine waxes, refined, 128-130 m.p. | lb. | .05 — .06 |
| Paraffine waxes, refined, 133-135 m.p. | lb. | .06 — .06½ |
| Paraffine waxes, refined, 135-137 m.p. | lb. | .06½ — .06½ |
| Stearic acid, single pressed | lb. | .11 — ..... |
| Stearic acid, double pressed | lb. | .11½ — ..... |
| Stearic acid, triple pressed | lb. | .12 — 12½ |

## Flotation Oils

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

| | | |
|---|---|---|
| Pine oil, steam dist., sp.gr., 0.930-0.940 | gal. | $1.70 |
| Pine oil, pure, dest. dist. | gal. | 1.60 |
| Pine tar oil, ref., sp.gr. 1.025-1.035 | gal. | .48 |
| Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla. | gal. | .35 |
| Pine tar oil, double ref., sp.gr. 0.965-0.990 | gal. | .75 |
| Pine tar, ref., thin, sp.gr., 1.080-1.960 | gal. | .36 |
| Turpentine, crude, sp. gr., 0.900-0.970 | gal. | 1.20 |
| Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990 | gal. | .37 |
| Pinewood creosote, ref. | gal. | .55 |

## Naval Stores

The following prices are f.o.b. New York for carload lots.

| | | | |
|---|---|---|---|
| Rosin B-D, bbl. | 280 lb. | $4.90 — | ..... |
| Rosin E-I | 280 lb. | 5.15 — | ..... |
| Rosin K-N | 280 lb. | 5.50 — | ..... |
| Rosin W. G.-W. W. | 280 lb. | 6.00 — | ..... |
| Wood rosin, bbl. | 280 lb. | 6.25 — | ..... |
| Spirits of turpentine | gal. | .57 — | ..... |
| Wood turpentine, steam dist | gal. | .56 — | ..... |
| Wood turpentine, dest. dist. | gal. | .55 — | ..... |
| Pine tar pitch, bbl. | 200 lb. | ..... — | 7.00 |
| Tar, kiln burned, bbl. (500 lb.) | bbl. | ..... — | 14.50 |
| Retort tar, bbl. | 500 lb. | 15.00 — | 14.75 |
| Rosin oil, first run | gal. | .45 — | ..... |
| Rosin oil, second run | gal. | .48 — | ..... |
| Rosin oil, third run | gal. | .60 — | ..... |

## Solvents

| | | |
|---|---|---|
| 73-75 deg., steel bbls. (85 lb.) | gal. | $0.41 |
| 70-72 deg., steel bbls. (85 lb.) | gal. | .39 |
| 68-70 deg., steel bbls. (85 lb.) | gal. | .38 |
| V. M. and P. naphtha, steel bbls. (85 lb.) | gal. | .30 |

## Crude Rubber

| | | | |
|---|---|---|---|
| Para—Upriver fine | lb. | $0.17 — | $0.18 |
| Upriver coarse | lb. | .11¾ — | .12½ |
| Upriver caucho ball | lb. | .14 — | .14½ |
| Plantation—First latex crepe | lb. | .18½ — | ..... |
| Ribbed smoked sheets | lb. | .16¾ — | ..... |
| Brown crepe, thin, clean | lb. | .18 — | ..... |
| Amber crepe No. 1 | lb. | .20 — | ..... |

## Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

| | | | |
|---|---|---|---|
| Castor oil, No. 3, in bbls. | lb. | $0.08¾ — | $0.09¼ |
| Castor oil, AA, in bbls. | lb. | 09¾ — | .10 |
| China wood oil, in bbls. (f.o.b. Pac. coast) | lb. | .07½ — | .08 |
| Cocoanut oil, Ceylon grade, in bbls. | lb. | .09¼ — | .10 |
| Cocoanut oil, Cochin grade, in bbls. | lb. | .10¼ — | .10½ |
| Corn oil, crude, in bbls. | lb. | .08 — | .08½ |
| Cottonseed oil, crude (f. o. b. mill) | lb. | .04 — | .04¼ |
| Cottonseed oil, summer yellow | lb. | .06 — | ..... |
| Cottonseed oil, winter yellow | lb. | .06½ — | ..... |
| Linseed oil, raw, car lots (domestic) | gal. | .62 — | ..... |
| Linseed oil, raw, tank cars (domestic) | gal. | .55 — | ..... |
| Linseed oil, in 5-bbl lots (domestic) | gal. | .65 — | .66 |

| | | | |
|---|---|---|---|
| Olive oil, commercial | gal | $1 90 | — $2 50 |
| Palm, Lagos | lb. | .07 | — .07½ |
| Palm, Niger | lb. | .06 | — .06½ |
| Peanut oil, crude, tank cars (f.o.b. mill) | lb. | .05½ | — .05½ |
| Peanut oil, refined, in bbls | lb. | .10 | — .10½ |
| Rapeseed oil, refined in bbls | gal. | 1 05 | — 1 10 |
| Rapeseed oil, blown, in bbls | gal. | 1 15 | — 1 20 |
| Soya bean oil (Manchurian), in bbls, N. Y. | lb. | .07½ | — .07½ |
| Soya bean oil, tank cars, f.o.b., Pacific coast | lb. | .04½ | — .... |
| **FISH** | | | |
| Light pressed menhaden | gal. | $0.45 | — $0.47 |
| Yellow bleached menhaden | gal. | .47 | — .... |
| White bleached menhaden | gal. | .49 | — .... |
| Blown menhaden | gal. | .84 | — .... |

## Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

| | | | |
|---|---|---|---|
| Barytes, ground, white, f.o.b. Kings Creek, S. C. | net ton | $24 00 | — 30 00 |
| Barytes, ground, off color, f.o.b. Kings Creek | net ton | 22 00 | — 26 00 |
| Barytes, crude, 88%@94% ba., Kings Creek | net ton | 10 00 | — 1[illegible] 00 |
| Barytes, floated, f.o.b. St. Louis | net ton | 26 50 | — 28 00 |
| Barytes, crude, first grade, Missouri | net ton | 10 00 | — .... |
| Blanc fixe, dry | lb. | .05 | — .05½ |
| Blanc fixe, pulp | net ton | 50 00 | — 60 00 |
| Casein | lb. | .14 | — .16 |
| Chalk, domestic, extra light | lb. | .05 | — .05½ |
| Chalk, domestic, light | lb. | .04½ | — .05 |
| Chalk, domestic, heavy | lb. | .04 | — .05 |
| Chalk, English, extra light | lb. | .05 | — .07 |
| Chalk, English, light | lb. | .05 | — .06 |
| Chalk, English, dense | lb. | .04½ | — .05 |
| China clay (kaolin) crude, f.o.b. mines, Georgia | net ton | 8 00 | — 10 00 |
| China clay (kaolin) washed, f.o.b. Georgia | net ton | 12 00 | — 15 00 |
| China clay (kaolin) powdered, f.o.b. Georgia | net ton | 18 00 | — 22 00 |
| China clay (kaolin) crude f.o.b. Virginia points | net ton | 8 00 | — 12 00 |
| China clay (kaolin) ground, f.o.b. Virginia points | net ton | 15 00 | — 4[illegible] 00 |
| China clay (kaolin), imported, lump | net ton | 23 00 | — 25 00 |
| China clay (kaolin), imported, powdered | net ton | 30 00 | — 35 00 |
| Feldspar, crude, f.o.b. Maryland and North Carolina points | gross ton | 8 00 | — 14 00 |
| Feldspar, crude, f.o.b. Maine | net ton | 7 50 | — 10 00 |
| Feldspar, ground, f.o.b. Maine | net ton | 21 00 | — 23 00 |
| Feldspar, ground, f.o.b. North Carolina | net ton | 17 00 | — 21 00 |
| Feldspar, ground, f.o.b. N. Y. State | net ton | 17 00 | — 21 00 |
| Feldspar, ground, f.o.b. Baltimore | net ton | 27 00 | — 30 00 |
| Fullers earth, f.o.b. Mines | net ton | 16 00 | — 17 00 |
| Fullers earth, granular, f.o.b. Fla | net ton | 25 00 | — .... |
| Fullers earth, powdered, f.o.b. Fla | net ton | 18 00 | — .... |
| Fullers earth, imported, powdered | net ton | 30 00 | — 35 00 |
| Graphite, Ceylon lump, first quality | lb. | .08 | — .09 |
| Graphite, Ceylon chip | lb. | .07 | — .08 |
| Graphite, high grade amorphous crude | lb. | .03 | — .03 |
| Pumice stone, imported, lump | lb. | .04 | — .50 |
| Pumice stone, domestic lump | lb. | .05 | — .05½ |
| Pumice stone, ground | lb. | .06 | — .07 |
| Quartz (acid tower) first to head, f.o.b. Baltimore | net ton | .... | — 10 00 |
| Quartz (acid tower) 1¼@2 in., f.o.b. Baltimore | net ton | .... | — 14 00 |
| Quartz (acid tower) rice, f.o.b. Baltimore | net ton | .... | — 17 00 |
| Quartz, lump, f.o.b. North Carolina | net ton | 5 00 | — 7 50 |
| Shellac, orange fine | lb. | .57 | — .... |
| Shellac, orange superfine | lb. | .60 | — .... |
| Shellac, A. C. garnet | lb. | .45 | — .... |
| Shellac, T. N. | lb. | .45 | — .... |
| Soapstone | ton | 12 00 | — 15 00 |
| Sodium chloride | long ton | 14 00 | — 15 00 |
| Talc, paper-making grades, f.o.b. Vermont | ton | 12 00 | — 22 00 |
| Talc, roofing grades, f.o.b. Vermont | ton | 9 50 | — 15 00 |
| Talc, rubber grades, f.o.b. Vermont | ton | 12 00 | — 18 00 |
| Talc, powdered, Southern, f.o.b. cars | ton | 12 00 | — 15 00 |
| Talc, imported | ton | 40 00 | — 50 00 |
| Talc, California talcum powder grade | ton | 20 00 | — 40 00 |

## Refractories

| | | | |
|---|---|---|---|
| Bauxite brick, 56% Al, f.o.b. Pittsburgh | | 1,000 | 160 |
| Carborundum refractory brick, 9-in. | less than carlot | 1,000 | 1250.00 |
| | carload lots | 1,000 | 1100.00 |
| Chrome brick, f.o.b. Eastern shipping points | net ton | | 80–100 |
| Chrome cement, 40–45% $Cr_2O_3$ | net ton | | 45– 50 |
| Chrome cement, 40–45% $Cr_2O_3$, sacks, in car lots, f.o.b. Eastern shipping points | net ton | .... | 55 |
| Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works | | 1,000 | 55– 60 |
| Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works | | 1,000 | 45– 50 |
| Magnesite brick, 9-in. straight | | net ton | 90 |
| Magnesite brick, 9-in. arches, wedges and keys | | net ton | 105 |
| Magnesite brick, soaps and splits | | net ton | 120 |
| Silica brick, 9-in. sizes, f.o.b. Chicago district | | 1,000 | 45– 55 |
| Silica brick, 9-in. sizes, f.o.b. Birmingham district | | 1,000 | 45– 55 |
| Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa | | 1,000 | 45– 55 |

## Ferro-Alloys

All f.o.b. Works

| | | | |
|---|---|---|---|
| Ferro-titanium, 15-18%, f.o.b. Niagara Falls, N. Y. | net ton | $200 00 | — $225.00 |
| Ferrochrome per lb. of Cr. contained, 6-8% carbon, carlots | lb. | .15 | — .16 |
| Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots | lb. | .16 | — .17 |
| Ferromanganese, 76-80% Mn, domestic | gross ton | 90 00 | — 95 00 |
| Ferromanganese, 76-80% Mn, English | gross ton | 90 00 | — 95 00 |
| Spiegeleisen, 18-22% Mn | gross ton | 32 00 | — 35 00 |
| Ferromolybdenum, 50-60% Mo, per lb. of Mo | lb. | 2 50 | — .... |
| Ferrosilicon, 10-15% | gross ton | 50 00 | — 55 00 |
| Ferrosilicon, 50% | gross ton | 85 00 | — 90 00 |
| Ferrosilicon, 75% | gross ton | 145 00 | — 150 00 |
| Ferrotungsten, 70-80%, per lb. of contained W | lb. | .45 | — .50 |
| Ferrouranium, 35-50% of U, per lb. of U content | lb. | 6 00 | — .... |
| Ferrovanadium, 30-40% per lb. of contained V | lb. | 5 00 | — 6.50 |

## Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

| | | | |
|---|---|---|---|
| Bauxite, 52% Al content | gross ton | $10.00 | — $11.00 |
| Chrome ore, Calif. concentrates, 50% min. $Cr_2O_3$ | unit | .45 | — .50 |
| Chrome ore, 50% $Cr_2O_3$, f.o.b. Atlantic seaboard | unit | .45 | — .50 |
| Coke, foundry, f.o.b. ovens | net ton | 5 00 | — 6 00 |
| Coke, furnace, f.o.b. ovens | net ton | 4 00 | — 5 00 |
| Coke, petroleum, refinery, Atlantic seaboard | net ton | 15 00 | — 16.00 |
| Fluorspar, lump, f.o.b. Hea hden, New Mexico | net ton | 17.50 | — .... |
| Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines | net ton | 22.50 | — 25.00 |
| Ilmenite, 52% $TiO_2$, per lb. ore | lb. | .01¼ | — .01½ |
| Manganese ore, 50% Mn, c.i.f. Atlantic seaport | unit | .30 | — .35 |
| Manganese ore, chemical ($MnO_2$) | gross ton | 60 00 | — 65.00 |
| Molybdenite, 85% $MoS_2$, per lb. of $MoS_2$, N. Y. | lb. | .55 | — .60 |
| Monazite, per unit of $ThO_2$, c.i.f., Atlantic seaport | unit | 30 00 | — .... |
| Pyrites, Spanish, fines, c.i.f., Atlantic seaport | unit | .16 | — .... |
| Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport | unit | .16 | — .... |
| Pyrites, domestic, fines, f.o.b. mines, Ga | unit | .12 | — .14 |
| Rutile, 95% $TiO_2$ per lb. ore | lb. | .15 | — .... |
| Tungsten, scheelite, 60% $WO_3$ and over, per unit of $WO_3$ (nominal) | unit | 3 00 | — 3.25 |
| Tungsten, Wolframite, 60% $WO_3$ and over, per unit of $WO_3$, N. Y. C. | unit | 3 00 | — 3.25 |
| Uranium ore (carnotite) per lb. of $U_3O_8$ | lb. | 1 50 | — 2 50 |
| Uranium oxide, 96% per lb. contained $U_3O_8$ | lb. | 2 25 | — 2 50 |
| Vanadium pentoxide, 99% | lb. | 12.00 | — 14.00 |
| Vanadium ore, per lb. of $V_2O_5$ contained | lb. | 1 50 | — .... |
| Zircon, washed, iron free | lb. | .03 | — .... |

## Non-Ferrous Metals

New York Markets

| | Cents per Lb. |
|---|---|
| Copper, electrolytic | 12.75 |
| Aluminum, 98 to 99 per cent. | 28.36@28.5 |
| Antimony, wholesale lots, Chinese and Japanese | 5¼@5½ |
| Nickel, ordinary (ingot) | 41.00 |
| Nickel, electrolytic | 44.00 |
| Monel metal, spot and bl eks | 35 |
| Monel me al ingots | 38 |
| Monel metal, sheet bars | 40 |
| Tin, 5-ton lots | 29.50 |
| Lead, New York, spot | 4.25@4.35 |
| Lead, E. St. Louis, spot | 4.25 |
| Zinc, spot, New York | 5.15 |
| Zinc, spot, E. St. Louis | 4.65 |

OTHER METALS

| | | |
|---|---|---|
| Silver (commercial) | oz. | $0.57½ |
| Cadmium | lb. | 1.00–1.10 |
| Bismuth (500 lb. lots) | lb. | 1.50@1.65 |
| Cobalt | lb. | 4.50 |
| Magnesium (f.o.b. Philadelphia) | lb. | 1.25 |
| Platinum | oz. | 72.00–74.00 |
| Iridium | oz. | 250.00@300.00 |
| Palladium | oz. | 65.00@70.00 |
| Mercury | 75 lb. | 45.00 |

FINISHED METAL PRODUCTS

| | Warehouse Price Cents per Lb. |
|---|---|
| Copper sheets, hot rolled | 20.00 |
| Copper bottoms | 27.50 |
| Copper rods | 18.75 |
| High brass wire | 18.25 |
| High brass rods | 15.25 |
| Low brass wire | 20.25 |
| Low brass rods | 20.25 |
| Brazed brass tubing | 29.50 |
| Brazed bronze tubing | 34.25 |
| Seamless copper tubing | 22.00 |
| Seamless high brass tubing | 21.00 |

**OLD METALS**—The following are the dealers' purchasing prices in cents per pound:

| | New York Current | New York One Year Ago | Cleveland | Chicago |
|---|---|---|---|---|
| Copper, heavy and crucible | 8.50@9.00 | 18.50 | 10.00 | 10.50 |
| Copper, heavy and wire | 8.00@8.25 | 16.50 | 9.50 | 9.50 |
| Copper, light and bottoms | 7.00@7.50 | 14.50 | 9.00 | 8.50 |
| Lead, heavy | 3.00@3.50 | 7.25 | 4.00 | 4.00 |
| Lead, tea | 2.00@2.12½ | 5.25 | 3.00 | 3.00 |
| Brass, heavy | 4.25@4.50 | 9.50 | 7.00 | 10.00 |
| Brass, light | 3.00@3.25 | 8.00 | 5.00 | 5.50 |
| No. 1 yellow brass turnings | 4.00@4.25 | 9.50 | 5.50 | 6.00 |
| Zinc | 2.00@2.50 | 5.00 | 3.00 | 3.50 |

## Structural Material

The following base prices per 100 lb. aref or structural shapes 3 in. by ¼ in. and arger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

| | New York *Current | New York One Month Ago | New York One Year Ago | Cleveland Current | Cleveland One Year Ago | Chicago Current | Chicago One Year Ago |
|---|---|---|---|---|---|---|---|
| Structural shapes | $2.59 | $3.80 | $3.47 | $3.58 | $3.37 | $3.58 | $3.47 |
| Soft steel bars | 2.50 | 3.70 | 3.52 | 3.34 | 3.27 | 3.48 | 3.52 |
| Soft steel bar shapes | 2.50 | 3.70 | 3.52 | 3.48 | 3.27 | 3.48 | 3.52 |
| Soft steel bands | 2.85 | 4.65 | 4.22 | 6.25 | .... | .... | .... |
| Plates, ¼ to 1 in. thick | 2.50 | 4.00 | 3.67 | 3.78 | 3.57 | 3.78 | 3.67 |

*Add 10c per 100 lb. for trucking to Jersey City and 15c for delivery in New York and Brooklyn

# Industrial

Financial, Construction and Manufacturers' News

## Construction and Operation

### California

LOS ANGELES — The All-In-One Mfg. Co., 504 Marsh-Strong Bldg., recently incorporated with a capital of $1,000,000 to manufacture metal enameled bathroom fixtures, has plans under way for its proposed new plant on a 10-acre site at Slauson Ave. and Downey Rd., lately acquired. The plant will consist of a group of eight main buildings, including 1-story foundry, 200x200 ft.; 1-story casting cleaning building, 50x200 ft.; 3-story enameling plant, 75x200 ft.; 1-story assembling building, 75x200 ft.; 1-story pattern shop, 50x200 ft.; warehouse and shipping building, office building, employees' building and garage. The new plant will cost about $350,000 with machinery. J. C. Peterson, Sacramento, Cal., vice-president of the company, will act as architect and engineer for the plant.

### Delaware

MILFORD—The Valliant Fertilizer Co., Laurel, Del., has acquired the fertilizer manufacturing plant of William Pierce, Milford. Possession will be taken at once and plans are under way for enlargements, to include the installation of new machinery. Edward S. Valliant will be manager of the Milford works.

### Illinois

ARGO—The Corn Products Refining Co. is reported to be planning for the early reopening of its local grinding works, recently closed temporarily. Since the first of the year the plant has been operating on a 4-day week basis. The works give employment to about 2,000 operatives.

CHICAGO — The American Magnesia Products Co., 106 North La Salle Street, is having plans prepared for extensions and improvements in its 2-story plant at 5726 Roosevelt Rd., to cost about $50,000. Bids will soon be asked.

CHICAGO—The Liberty Raw Hide Mfg. Co., 1435 West Austin Ave., is having plans prepared for the erection of a 2-story addition to its plant, estimated to cost about $12,000.

CHICAGO—C. F. Davis & Co., Inc., dealer in tin plate and sheet metals, is planning the erection of a new plant at 37th St. near Iron. The investment including lot, 132x135 ft., will be approximately $65,000. There will be about 15,000 sq.ft. of floor space. The main offices of the company will be located in the new building. This company also has branch offices and warehouses in New York and Pittsburgh.

CHICAGO—The Illinois Brick Co. has purchased the 26 acres bounded by Sacramento, Lunt and California Aves. and Pratt Blvd. This property consists of a clay bank acquired with the intention of extending the company's plant at some future date.

### Indiana

VINCENNES—A portion of the plant of the Indian Refining Co., manufacturer of oils, was destroyed by fire March 26, with loss reported at about $150,000.

### Kentucky

LOUISVILLE—The Louisville Soap Products is planning for the rebuilding of its plant destroyed by fire March 27, with loss estimated at $270,000.

### Maine

GREAT WORKS—The Penobscot Chemical Fibre Co. has completed the construction of a new digester building at its plant and plans to place the structure in service at an early date.

WATERVILLE—The Keyes Fibre Co., Fairfield Rd., has awarded a contract to the Horace Purington Co., 178 Main St. for the construction of three additions to its plant, consisting of a 2-story machine and pump department, 45x95 ft.; 1-story pulp works, 40x150 ft.; and 1-story drier building, 90x140 ft.

### Maryland

BALTIMORE — The Zirconium Co. of America, recently organized with a capital of $1,000,000 to manufacture ferrozirconium and a refractory specialty known as zirconium oxide, has acquired an interest in the plant of the Rare Metals Reduction Co., Old Frederick Rd., Catonsville, and will use the property in connection with its proposed new plant in this section. George F. Dixon is president and Philip C. Spencer vice-president.

MOUNT SAVAGE—The Mount Savage Fire Brick Co. has awarded a contract to Golin Gerlach, Frostburg, Md., for the construction of additions to its plant to cost about $85,000. The work will consist of a new kiln building, 100x200 ft., and two other buildings, 98x286 ft., and 36x325 ft., respectively, with power house, 50x90 ft.

BALTIMORE—The Crown Oil & Wax Co., Eighth and Pratt Sts., is said to be planning for extensions and improvements at its plant to cost about $25,000.

BALTIMORE—The Cooknut Corp., Lexington and Paca Sts., W. R. Spruill, president, recently organized with a capital of $500,000 to manufacture lard substitutes and kindred products, is planning for the early erection of the first unit of its proposed new plant, to have an initial capacity of about 55,000 lb. per day.

### Michigan

ROCKFORD—Machinery will be installed at once at the new local plant of Henry Ford, Detroit, for the manufacture of plate glass under a new process. A large portion of the output will be used for Ford automobiles. The company has extensive silica deposits in this section, claimed to be particularly suitable for the desired character of glass.

### Missouri

KANSAS CITY—The Barada, Gordon & Page Chemical Co., 2018 Guinotte St., has awarded a contract to the McCallum Construction Co. for the erection of a new plant, 40x60 ft., on Michigan Ave.

### New Jersey

PERTH AMBOY—Fire April 6 destroyed a portion of the local plant of the General Bakelite Co., 350 Rector St., with loss estimated at about $15,000.

### New York

BUFFALO—The Standard Milling Co., 49 Wall St., New York, has plans under way for its proposed new flour mill at the foot of Louisiana St., Buffalo. The mill, it is said, will be the largest plant of its kind in the world. It will comprise two elevators of 3,500,000 and 2,500,000 bu. capacity, respectively. Four complete flour mill units will be constructed, each with an output of 6,000 bbl. per day; a rye mill of 300 bbl. daily output; wheat mill of 300 bbl. capacity; corn mill of 500 bbl.; and oatmeal of 600 bbl. The new plant with machinery is estimated to cost about $7,500,000. The A. E. Baxter Engineering Co., Ellicott Sq., Buffalo, is engineer.

CORNING—The Illig Cut Glass Co., East Market St., will soon take bids for the erection of a 1-story addition at Denison Parkway and Pearl St., 45x45 ft. John Illig is head.

### Ohio

BREMAN—The Breman Metal Stamping Co. has plans under way for the erection of a 1-story addition, 28x70 ft. W. E. Trinkey is head.

LANCASTER—The Interstate Glass Co., Bradford, Pa., is having plans prepared for extensions and improvements in its plant at Lancaster to cost about $70,000. H. J. Walters is president and general manager.

CAMBRIDGE—The Flannagan Pottery Co. has awarded a contract to Gamble & Bryan, East Liverpool, O., for the erection of a new kiln building to cost about $20,000. It will be used for decorative work.

### Oregon

PORTLAND — The Portland Flouring Mills Co. has arranged for a bond issue of $3,000,000, the proceeds to be used, in parts, for proposed extensions and betterments in its different plants.

### Pennsylvania

PITTSBURGH—Fire March 31 destroyed a portion of the building of the Pennsylvania Paper Stock Co., with loss estimated at close to $100,000.

PITTSBURGH—The Air Reduction Co., 2555 Liberty St. and 120 B'way, New York, manufacturer of commercial oxygen, etc., is having revised plans prepared for the erection of its proposed new plant on Ridge Ave. to cost about $250,000 with equipment.

PORT KENNEDY — The Valley Forge Magnesia Co. has awarded a contract to the William Steele & Sons Co., 1600 Arch St., Philadelphia, for the erection of its proposed new local plant, comprising a 2-story building, 40x100 ft., and 1-story structure, 40x48 ft.

### Tennessee

KNOXVILLE — H. L. Dullin, affiliated with Anderson, Dullin & Varnell, is organizing a new company for the establishment of a new plant for the production of acid phosphate and kindred specialties.

KNOXVILLE—The Knoxville Fertilizer Co., recently organized with a capital of $500,000, has plans under way for the erection of a new local plant. James W. Dean and S. B. Carter head the company.

MARTIN—The E. E. Gooch Mfg. Co., recently organized, is planning for the erection of a new plant for the manufacture of Skipper and other compounds. The installation will consist of grinding and mixing machinery, packing equipment, etc. The different machines will be electrically operated. E. E. Gooch is president and general manager.

### Texas

HOUSTON—The Standard Rubber Co., Mason Bldg., has acquired the plant of the Universal Tire Co. for the establishment of a new rubber goods manufacturing plant. It is said that the plant will be remodeled and improved. E. H. Fleming is president and John T. Powers, Jr., secretary.

SAN ANTONIO—The Samuels Art Glass Co. has acquired a local site with about 100 ft. frontage for the construction of a new 3-story plant. L. M. Samuels is head.

SAN ANTONIO—Charles R. Tips, San Antonio, is organizing a new company for the construction of a glass-manufacturing plant at Three Rivers, near San Antonio. The initial works will be of 3-tank type, and will be devoted exclusively to bottle production. The company has its own silica properties in this district. The new plant is estimated to cost about $30,000.

### Washington

SPOKANE—The Northwest Iron & Steel Co., Rookery Bldg., is planning for the erection of a new iron furnace in the Boundary district of Stevens County. The plant will have an initial output of 25 tons per day, and at a later date, it is said, will be enlarged and improved.

### West Virginia

ELLENBORO — The Insulite Co., recently organized to manufacture molded composition products, etc., has awarded a contract to J. M. Worstell, Ellenboro, for the construction of its proposed new plant, 80x160 ft. A number of machine tools in addition to regular operating equipment will be installed, including lathes, drills, grinders, etc. A power house also will be constructed. Edward J. White is president and manager.

HUNTINGTON—The International Nickel Co., 42 Exchange Pl., New York, has awarded a contract to the McClintic-Marshall Co., Oliver Bldg., Pittsburgh, Pa., for the erection of its proposed new plant at Huntington for the manufacture of rolled nickel products. The plant will consist of a group of 1-story buildings, approximating 200x400 ft. in size, including rolling mill and other departments. It is estimated to cost in excess of $2,000,000 with machinery. Frank I. Ellis, Farmers' Bank Bldg., Pittsburgh, is consulting engineer for the project.

SUTTON — The Sutton Building Corp., recently organized, is planning for the erection of a local plant for the manufacture of brick, tile and other burned clay products. Benton B. Boggs is president.

# New Companies

THE SUPERIOR SPARK PLUG Co., Detroit, Mich., has been incorporated with a capital of $25,000 to manufacture spark plugs and other ignition equipment. The incorporators are I. J. Pettiford, Z. W. Laskalin and George Hadrich, 4001 Bewick Ave.

THE INTERNATIONAL ENGINEERING & CHEMICAL CORP., Boston, Mass., has been incorporated with a capital of 1,000 shares of stock, no par value, to manufacture chemicals and chemical byproducts. The incorporators are C. Binnig, Benjamin J. Phipps and Samuel Arafe, 41 Draper St., Dorchester, Mass.

THE DRAGON DRUG & CHEMICAL Co., Brooklyn, N. Y., has been incorporated with a capital of $300,000 to manufacture chemical products. The incorporators are G. B. Rose, S. Marchisio and J. Furcht, 26 Court St.

THE J. J. MURPHY PAPER Co., New York, N. Y., has been incorporated with a capital of $125,000 to manufacture paper products. The incorporators are M. Syrkin, A. Aaronson and J. J. Murphy, Orange, N. J.

THE DE LUXE INK & DYE Co., 716 Ashland Blk., Chicago, Ill., has been incorporated with a capital of $40,000 to manufacture ink, dyes and kindred products. The incorporators are Sampson Andalman, M. King Schrager and Samuel J. Green.

THE MOSCO REFINING Co., Newark, N. J., has been incorporated with a capital of $25,000 to manufacture oil products. The incorporators are John J. McLean, Charles S. Halleron and William D. Duguid, 87 Irving St.

THE BAY STATE FIBRE Co., Portland, Me., has been incorporated with a capital of $10,000 to manufacture fiber products. E. M. Pine is president; Edmund P. Mahoney, treasurer; and Jacob H. Berman, secretary.

THE EUCO CHEMICAL Co., Tonawanda, N. Y., has been incorporated with a capital of $25,000 to manufacture chemicals and byproducts. The incorporators are G. L. Corliss, C. L. Pack and W. W. Britt, Tonawanda.

THE SAGINAW CLAY PRODUCTS Co., Saginaw, Mich., has been incorporated with a capital of $30,000 to manufacture burned clay specialties. The incorporators are F. J. Lohman, Henry W. F. and J. Fred Goetz, Saginaw.

THE LOS ANGELES-VENTURA OIL Co., Los Angeles, Cal., has been incorporated with a capital of $500,000 to manufacture petroleum products. The incorporators are J. B. Harker, Charles I. Puffer and M. H. Serf, Los Angeles. The company is represented by C. E. Hobart, 500 Wilcox Bldg.

THE NORTH WEST ENVELOPE Co., Seattle, Wash., has been incorporated with a capital of $50,000 to manufacture paper products. The incorporators are I. V. Carey and associates.

THE MERIT OIL Co., 355 East 47th St., Chicago, Ill., has been incorporated with a capital of $20,000 to manufacture oil products. The incorporators are Leo and Jacob Adler, and Charles A. Schram.

THE VELVO OIL Co., Utica, N. Y., has been incorporated with a capital of $150,000 to manufacture refined oil products. The incorporators are F. A. Hoyt, J. A. Ritchie and F. M. Tobin, Utica.

THE COLUMBIA CHEMICAL CONSTRUCTIVE CORP., Philadelphia, Pa., has been incorporated under Delaware laws with a capital of $100,000 to manufacture chemicals and chemical byproducts. The incorporators are Fred J. Bergmann, Fred W. Moesta and Edward Ramsey, Philadelphia.

THE INDUSTRIAL MOLDED MATERIALS Co., Woodbury, N. J., has been incorporated with a capital of 2,500 shares of stock, no par value, to manufacture molded and compounded specialties. The incorporators are Harry M. Dent, Robert G. Griswold and Paul Knapp, Woodbury.

THE LEO DREYFUS Co., New York, N. Y. has been incorporated with a capital of $250,000 to manufacture chemicals and chemical byproducts. The incorporators are L. Dreyfus, S. D. Kessler and J. Herron, Jr. R. Seelav, 51 Chambers St., New York, represents the company.

THE BURGESS PAPER Co., 37 West Van Buren St., Chicago, Ill., has been incorporated with a capital of $20,000 to manufacture paper specialties. The incorporators are Roy H. and Frank A. Burgess, and Edwin I. Hoke.

THE CHEMICAL GAS DEVELOPMENT Co., Vancouver, Wash., has been incorporated with a capital of $300,000 to manufacture chemical products. The incorporators are A. S. Battson, E. D. Payne and F. L. Naul, Vancouver.

THE SUPERSOAP PRODUCTS Co., New York, N. Y., has been incorporated with a capital of $10,000 to manufacture soap and kindred products. The incorporators are J. Sokoloff, M. M. Sokoloff and J. Stollmaker, 162 East 161st St., Bronx.

THE WILLARD BRICK Co., New York, N. Y., has been incorporated with a capital of $50,000 to manufacture brick and other burned clay products. The incorporators are A. F. Hanrahan, W. F. Davis and E. A. Vosseler. The company is represented by E. W. Webb, 149 B'way.

THE HUNTINGTON OWNERS' OIL Co., Los Angeles, Cal., has been incorporated with a capital of $500,000 to manufacture petroleum products. The incorporators are J. E. Yerby, B. S. Carr and M. P. Hansen. B. S. Hunter, Citizens' National Bank Bldg., represents the company.

THE APEX OIL Co., Los Angeles, Cal., has been incorporated with a capital of $1,000,000 to manufacture petroleum products. The incorporators are Arthur G. Gage, Fred H. Hammer and M. L. Jenks. The company is represented by Adams, Adams & Binford, 716 Van Nuys Bldg.

THE FORT WORTH ENVELOPE Co., Fort Worth, Tex., has been incorporated with a capital of $10,000 to manufacture paper products. The incorporators are J. A. Stafford, E. C. and W. C. Lowden.

THE CHEMICAL PRODUCTS Co. OF NEW JERSEY, INC., Newark, N. J., has been incorporated with a capital of $1,000,000 to manufacture chemicals and chemical byproducts. The incorporators are George A. Soden and Alfred Gable, Newark; and S. Ellsworth White, Glen Ridge, N. J.

THE MONUMENTAL OIL CORP., Baltimore, Md., has been incorporated with a capital of $25,000 to manufacture lubricating oils, greases, etc. The incorporators are Howard M. Roberts, Stuart S. Scott and Charles D. Smith, 110 South Charles St.

THE ALLOY ORE & MINERAL Co., 128 Market St., Newark, N. J., has filed notice of organization to manufacture alloys, ore specialties, etc. Irving N. Schafman, 212 Elizabeth Ave., heads the company. The same interests have formed the Asbestos & Magnesia Co., Superb Bldg., to manufacture asbestos products, and the Atlantic Gulf & Pacific Oil Co., to manufacture oil specialties.

THE R. A. HUDSON Co., Auburn, N. Y., has been incorporated with a capital of $175,000 to manufacture chemical and chemical byproducts, drugs, etc. The incorporators are N. D. Stone, W. T. and R. A. Hudson, Auburn.

THE MID-WEST DRUG Co., Akron, O., has been incorporated under Delaware laws with a capital of $100,000 to manufacture chemicals, drugs and affiliated products. The incorporators are Edgar M. Williams, Akron; Albert B. Smith, Chicago; and L. J. Rothenbecker, Cleveland, O.

THE ART PARAGON PAPER BOX Co., 531 South Peoria St., Chicago, Ill., has been incorporated with a capital of $20,000 to manufacture paper boxes and kindred specialties. The incorporators are Abraham, Louis S. and Samuel S. Berman.

R. A. FAWCETT, INC., Boston, Mass., has been incorporated with a capital of $50,000 to operate a leather tanning plant for hides, skins, and for the production of byproducts. The incorporators are Benjamin Hemmerlin, 161 Summer St.; A. T. Parsons and L. A. Smith, Boston.

THE AUTO CITY OIL Co., Detroit, Mich., has been incorporated with a capital of $10,000 to manufacture lubricating oils. The incorporators are Marble I. Tweedle and August L. Miller, 5441 Iroquois Ave., Detroit; and W. H. Stavk, Cleveland, O.

THE INTERSTATE TANNING Co., Newark, N. J., has been incorporated with a capital of 2,500 shares of stock, no par value, to manufacture leather products. The incorporators are W. R. Crosson, Willard S. Muchmore and A. P. Bachman. The company is represented by James B. Reilly, 31 Clinton St.

THE TRENTON FOLDING BOX Co., Trenton, N. J., has been incorporated with a capital of $125,000 to manufacture paper boxes and kindred products. The incorporators are A. E. Serridge, Edwin W. Arnold and George F. Vanaken, Trenton.

THE ARUNDEL OIL CORP., 7 East Redwood St., Baltimore, Md., has been incorporated with a capital of $400,000 to manufacture oil products. The incorporators are William A. Smith, Bruner R. Anderson and John A. Vogt.

THE KEYSTONE FIREBRICK Co., Philadelphia, Pa., has been incorporated with a capital of $150,000 to manufacture firebrick and other refractory products. The incorporators are A. M. Davis, James Warnock, Philadelphia; and Walter L. Hachnlen, Cynwyd, Pa.

THE CHARLES E. LESTER Co., New York, N. Y., has been incorporated with a capital of $20,000 to manufacture chemical products. The incorporators are E. S. Bachrach, D. Rieser and W. Strauss. H. Hofheimer, 35 Nassau St., represents the company.

# Coming Meetings and Events

AMERICAN CHEMICAL SOCIETY will hold its sixty-first meeting at Rochester, N. Y., April 26 to 29. Headquarters will be at the Hotel Rochester.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting at Atlantic City April 21 to 23 inclusive. Headquarters will be at the Hotel Chalfonte.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its spring meeting June 20 to 24 at Detroit. Industrial excursions will be made to Ann Arbor, Saginaw, Midland and Bay City.

AMERICAN LEATHER CHEMISTS ASSOCIATION will hold its eighteenth annual meeting at the Hotel Ambassador, Atlantic City, June 9, 10 and 11.

AMERICAN MINING CONGRESS AND NATIONAL EXPOSITION OF MINES AND MINING EQUIPMENT will hold its twenty-fourth annual convention in the Coliseum, Chicago, Oct. 17 to 22.

AMERICAN OIL CHEMISTS' SOCIETY (formerly the Society of Cotton Products Analysts) will hold its twelfth annual meeting in Chicago May 16 to 17. Headquarters will be at the Congress Hotel.

AMERICAN PAPER & PULP ASSOCIATION is holding its annual meeting at the Waldorf-Astoria and Hotel Astor, New York City, April 11 to 15.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS will hold its spring meeting at the Congress Hotel, Chicago, May 23 to 26.

AMERICAN SOCIETY FOR STEEL TREATING will hold its third annual convention and exhibition Sept. 19 to 24 at Indianapolis.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 1921 annual meeting in the New Monterey Hotel, Asbury Park, N. J., during the week of June 20.

AMERICAN WELDING SOCIETY, METROPOLITAN SECTION, will hold its regular meeting April 19 at the Engineering Societies Building, New York City.

AMERICAN ZINC INSTITUTE will hold its annual meeting in St. Louis May 9 and 10.

ASSOCIATION OF SCIENTIFIC APPARATUS MAKERS OF THE U. S. A. will hold its meeting at the Hotel Raleigh, Washington, D. C., April 14 to 16.

BRITISH IRON AND STEEL INSTITUTE will hold its spring meeting May 5 and 6, at the Institution of Civil Engineers, Great George St., S. W. 1, London, England.

CHAMBER OF COMMERCE OF THE UNITED STATES will hold its ninth annual meeting in Atlantic City April 27, 28 and 29.

HARVARD ALUMNI CHEMISTS' ASSOCIATION will meet Tuesday noon, April 26, at Rochester, N. Y., for luncheon.

THE NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES (SEVENTH) will be held during the week of Sept. 12, in the Eighth Coast Artillery Armory, New York City.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

SOCIETY OF INDUSTRIAL ENGINEERS will hold a meeting in Milwaukee April 27 to 29.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

TECHNICAL ASSOCIATION OF THE PULP & PAPER INDUSTRY is holding its annual meeting at the Waldorf-Astoria and Hotel Astor, N. Y., April 11 to 14.

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: April 22, Society of Chemical Industry, joint meeting with American Electrochemical Society, Société de Chimie Industrielle and American Chemical Society; May 6, American Chemical Society, Nichols Medal award; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.